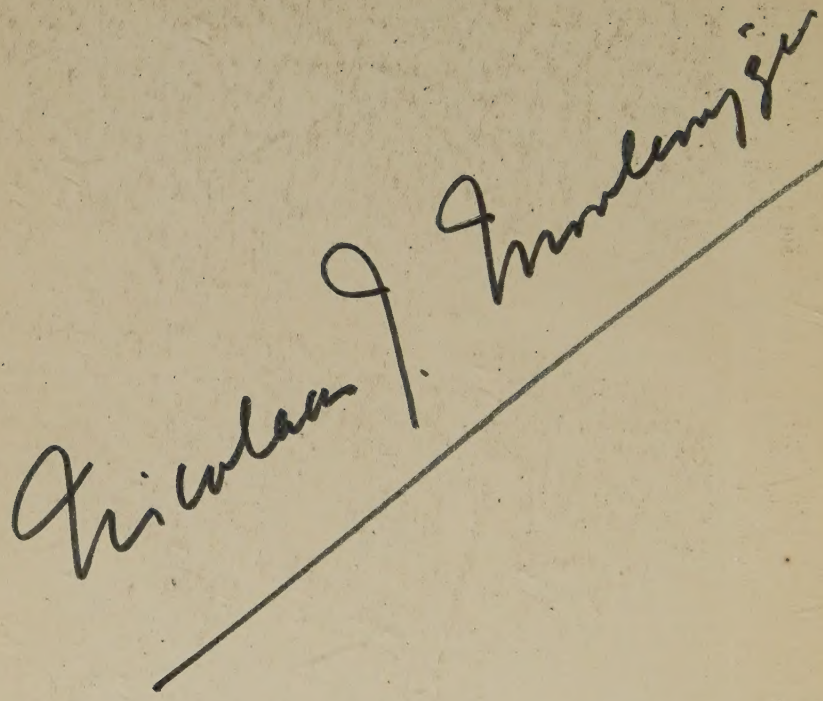
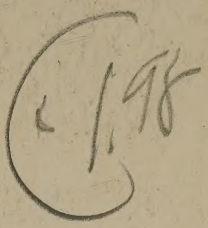
Physical Education
By Muscular Exercise

Gulick



Tilden H. Stearns
Harvard University,
Cambridge Y. M. C. A.



PHYSICAL EDUCATION

GULICK

When Prompt Action is Necessary

ACCIDENTS AND EMERGENCIES

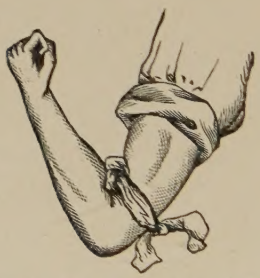
By CHARLES W. DULLES, M.D.

will be found an Unfailing Guide

Fifth Edition, with new illustrations, some in color, indicating plainly the manual treatment prescribed

---

12mo. Cloth. Net, $1.00



How to stop bleeding of main blood-vessel of the arm

This valuable little manual has been written with the object of detailing concisely the best course to pursue for the speedy relief of injured persons, till the arrival of skilled assistance, including poisoning, drowning, fractures, hemorrhages, wounds, etc.

St. Louis, Nov. 67

PHYSICAL EDUCATION

BY

MUSCULAR EXERCISE

LUTHER HALSEY GULICK, M.D.,

DIRECTOR OF PHYSICAL TRAINING IN THE PUBLIC SCHOOLS OF GREATER NEW YORK; PRESIDENT OF AMERICAN PHYSICAL EDUCATION SOCIETY, ETC.

Illustrated

PHILADELPHIA

P. BLAKISTON'S SON & CO.

1012 WALNUT STREET

1904

COPYRIGHT, 1904, BY P. BLAKISTON'S SON & CO.

REPRINTED FROM VOL. VII OF "COHEN'S SYSTEM OF PHYSIOLOGIC THERAPEUTICS," PHILADELPHIA,
P. BLAKISTON'S SON & CO.

PREFACE

The material in this little book grew up gradually through the exigencies of a lecture course on the Philosophy of Exercise. The subject-matter appeared in the "Y. M. C. A. Athletic League Letter" in 1899–1900.

The range of topics discussed indicates my indebtedness to many persons. My first impulses toward working out my own thought on the subject came from my instructor, Dr. Dudley Allen Sargent, of Harvard University. The direction of my study was largely influenced for years by Dr. E. M. Hartwell, then of Johns Hopkins. To the inspiration of President G. Stanley Hall I owe the biologic point of view. To Dr. Wm. T. Harris I owe my first thought in regard to the relation of exercise to the vegetative processes. To Dr. T. M. Balliet, Superintendent of Schools, I also owe much. I do not wish to saddle these gentlemen with the responsibility for these ideas, for many of them are my own.

If I have succeeded in my endeavor this book will be of service to those who wish a general view of the subject, whether for use in medicine or education.

L. H. G.

TABLE OF CONTENTS

CHAPTER I

PAGES

EXERCISE AND DEVELOPMENT, ... 1–28

General Aim, 1. Exercise and Evolution, 2. City and Exercise, 3. Occupation, 3. Schools, 4. Balance between Neural and Muscular Expenditure, 5. Special Classes, 6. Exercise in Accordance with Function, 7. Physiology of Exercise, 9: Effect upon the Muscle-cell, 9; Effect on the Body as a Whole, 9; Special Effects of Muscular Exercise, 10; Position during Exercise, 11; Physiologic Load, 13. Neurologic Considerations, 15: Moderate and Excessive Exercise, 16; Physical Exercise and Cerebral Development of the Brain, 17; Fatigue, 18; Co-operation among Contiguous Nerve-centers, 18; Muscular Contraction and Psychic Activity, 21. Limits of Specialization in Exercise, 24; Somatic Harmony, 25; Competition, 26. Dosage of Exercise, 26.

CHAPTER II

MATERIA GYMNASTICA; SPORTS AND GAMES; SYSTEMS OF GYMNASTICS, ... 29–64

Walking and Running, 29. Calisthenics, 31. Pulley-weight Exercise, 33. Heavy Gymnastic Apparatus Exercises, 37. Track and Field Athletics, 39. Athletic Games, 39. Wrestling, Boxing and Fencing, 41. Bicycling, 42. Golf, 43. Horseback-riding, 43. Bowling, 43. Rowing, 44. Relation of Physical Exercise to Age and Sex, 44. Baseball, Cricket, Hockey, Shinney, Basket ball, 46. Football, 47. MEDICALLY CONSIDERED: Condition, 51; Habit, 52; Strength, 53; Endurance, 53. SYSTEMS OF GYMNASTICS: German Gymnastics, 54; Swedish Gymnastics, 56; English Physical Exercises, 58; Delsarte, 59; Sargent, 60; Emerson, 61; Young Men's Christian Associations, 62. Dancing, 63.

INDEX 65

PHYSICAL EDUCATION BY MUSCULAR EXERCISE

CHAPTER I

EXERCISE AND DEVELOPMENT

General Aim. Exercise and Evolution. City and Exercise. Occupation. Schools. Balance between Neural and Muscular Expenditure. Special Classes. Exercise in Accordance with Function. Physiology of Exercise: Effect on the Muscle-cell; Effect on the Body as a Whole; Special Effects of Muscular Exercise; Position during Exercise; Physiologic Load. Neurologic Considerations: Moderate and Excessive Exercise; Physical Exercise and Cerebral Development of the Brain; Fatigue; Co-operation among Contiguous Nerve-centers; Muscular Contraction and Psychic Activity. Limits of Specialization in Exercise; Somatic Harmony; Competition. Dosage of Exercise.

General Aim

For our purposes muscular exercise may be considered from three viewpoints:

1. In relation to its use as a **definite remedial measure** in a few pathologic conditions.

2. In relation to the **development** of the individual in **structure** and **function.**

3. In relation to **general somatic vigor.** Somatic vigor is the essence of that power of resistance which the organism shows to the invasion of disease. It is well known that the power of resistance varies much in the individual from time to time; pathogenic bacteria will at one time be destroyed promptly, while at another they will gain a foothold and multiply.

Disease must be avoided by the prevention of inoculation; but, what is of equal importance, it must be averted by the maintenance of such

bodily vigor that the maximum of resistance will be offered by the organism itself.

Special Considerations.—The physician has three questions to answer about muscular exercise:

1. What specific exercises will be effective in given **pathologic states?** Under this head I discuss nothing here. It is my province to examine the general effects of exercise together with the detailed effects of specific exercises and sports.

2. What character and quantity of exercise are needed for the growing organism, to insure **balanced development?** Physicians must pass upon the claims of various systems of gymnastics that are offered for adoption by schools, as well as upon the necessity for, and the character of, work outside of school. It is hoped that the data given will be sufficient for full and intelligent answers to these questions.

3. What exercises are best adapted under various conditions, such as age, sex, and the like, to render most active the **general somatic life** of the individual? This question I hope to answer with some degree of definiteness.

I am aware that some of the more important conclusions here set forth are not in accord with the accepted doctrines of many teachers of physical training; yet these views will be seen to have their justification both in clinical experience and in biologic science. While I shall in the main confine my work to conclusions and their practical application, certain **preliminary considerations** need to be stated, to form a rational basis for the practical directions that follow.

Exercise and Evolution.—Those conditions under which the body was given its present size, shape, and structure are in general the conditions adapted to maintaining the fullest functional activity. During the unnumbered years of evolutionary time, muscular exercise in labor, war, or the chase has been one of the major elements of human experience. Upon neuromuscular ability the race has depended for survival, even when its ancestors were in a condition of development yet more elementary than that of savage life. A biologist, having brought to him a human body and being asked for a statement of its functions from an examination of the structure, would say that both in form and function the organism must have been adapted to a life of considerable muscular exertion; that this appeared, first, from the proportions of the muscular system; that the lungs as well as the heart indicated far more capacity than would be needed for a life exclusively or even largely sedentary; and, finally, that the nervous system was designed predominantly for

the initiation or control of muscular movements. The health of such an organism depends upon the balanced co-operation of all its parts. These parts have become adjusted to a certain general balance in the activities of the nutritive, neural, and muscular tissues. No argument is necessary to the evolutionist to show that the necessity for muscular exercise has been constant and predominant throughout the whole history of the life of the species; that it has been so constant and so large a factor in adjustment to the total environment as to have had a chief share in determining the character of the organism itself; and that those conditions which have been decisive in determining the form and functions of the organism are the conditions in which it functionates the best.

The argument for muscular exercise from the standpoint of evolution is thus the strongest that can be presented. The environment of the organism cannot be changed in other respects with impunity. Man has become adapted to breathing air of a certain approximate constitution, and he is at his best in this environment. He has become measurably able to carry his environment with him with reference, for instance, to temperature, and somewhat with reference to light; but the general fact remains that perfect adaptation to environment is most definitely related to health.

City and Exercise.—Man has by conscious direction so utilized artificial coverings as to be able to maintain a certain thermic environment in spite of variations in the natural temperature of the atmosphere. The time is rapidly approaching when he must generally take as consciously under his direction the matter of muscular exercise, because the process of civilization is taking away from him those natural demands for muscular exercise which have been its efficient cause during the ages of evolution. The conditions of human life in civilized countries have changed more since the development of the steam-engine than they had for thousands of years previously. In the United States the proportion of steam power to manual labor is represented by a steam-engine of $11\frac{1}{2}$ horse-power to every male adult inhabitant. The bulk of the heavy work in the civilized world is done by machinery and not by human muscles. There is still a good deal of muscular work performed, but it is decreasing rapidly. It is least among the most civilized peoples, and among these peoples is least among the most civilized classes. The management of machinery demands not muscular force, but muscular skill and intelligence.

Occupation.—In connection with this specialization, there have arisen a whole group of so-called **diseases of occupation,** some of these related definitely to the specialization itself—such as writer's cramp.

In the handling of machinery the tendency is to have individuals make comparatively few movements many times. The more general activities of early farm life called for a far more varied set of muscular movements. For example, personal experience on the farm for a short period embraced the following forms of exercise: driving the cows home and milking them, caring for horses and stables, sharpening tools, handling hay and grain with pitchfork, driving a horse-rake, digging potatoes, cleansing large milk cans, making wooden handles for tools, dish-washing, building rail fence, chopping wood, helping with cross-cut saw (two men), working on a threshing-machine, hoeing weeds in a potato patch, husking corn, sawing wood with a buck-saw, repairing in woodwork, helping to build a stone fence, digging out woodchucks, hunting gray squirrels, and a multitude of minor exertions that slip the memory. Let these activities be compared with those of the mill operative who "tends a machine" of some kind, or with those of the salesman in a store, or the clerk in a bank, and the contrast becomes evident.

Finally, it is to be remembered that the process of urbanization is a progressive one, needing continually greater attention from the physician. In 1790 considerably less than 4 per cent. of the population of the United States lived in cities and villages. A general comparison with the present condition is hardly fair because of the immense tracts of sparsely settled country that have been acquired since then; but in spite of this, the census of 1900 (Abstract of Census, page 38) shows that only 59.8 per cent. of the population are now classified as living in country districts. The change from 96 per cent. to 59.8 per cent. in one hundred and ten years is instructive. The lesson is still more dramatically told by a study of the urban growth in some of the more stable eastern States Massachusetts has only 8.5 per cent. in country districts, Connecticut 25.1 per cent., New Jersey 29.4 per cent., New York 27.1 per cent., Rhode Island 5 per cent.

Schools.—Another process that is rendering conscious attention to muscular exercise necessary is the growth in school population, and the increase in the length of time during which children go to school. In 1840, out of a total population of 17,069,453, there was a school population of 2,025,565, or 11 per cent. In 1890, out of a total population of 62,622,250, there was a school population of 14,768,965, or 23 per cent. The normal life of the child is one of steady activity during the waking hours. We are taking away for five hours a day a large part of this activity. It will be shown further on that exercise is fundamentally related to growth, so that the harmfulness of this lessening of exercise by school limitations during the early years of life is readily seen. Not only

is muscular exercise decreased by school life, but pressure is brought to bear to increase the attention to psychic things. Thus, there is a coincident decrease in muscular expenditure and an increase in lines that are purely neural.

Intercommunication.—There are further factors that are changing the balance between the neural and muscular expenditures of the body; for instance, in modern life the growth of the news-communicating agencies, shown not only in the tremendous increase in the postal service, but in the development of the telegraph, the telephone, and the daily press. Two kinds of results may be traced to these sources:

1. A vast increase in the amount of business done in a given time, without any decrease in the necessary expenditure of thought. That the modern business man accomplishes a vastly greater quantity of business than his ancestors did in the same length of time is as evident to those who are familiar with modern conditions as it is impossible to set forth statistically.

2. News-communicating agencies bring us into contact with the whole world as never before, and thus emotion, which is a peculiarly exhausting form of psychic activity, is stimulated. The daily press deluges our minds with the tragic occurrences of the world. Then, again, the development of city life diminishes the amount of sunshine that the average individual will get, and in most cases also the quantity of fresh air. The tremendous growth in the use of drugs affecting the nervous system reflects a corresponding increase in disorders of that system. The increase in women's diseases with the progress of civilization, and the decrease in the muscular work of women, are more than mere coincidence, as is shown by the comparatively robust health of women who do regular physical work; even when it is carried on to the extent found among female acrobats working in circuses, we still find great health and vigor, contrasting markedly with the health of women whose lives have but little of muscular activity. Attention has frequently been called to the inferiority of stock born and bred in the conditions of city life. This was first pointed out by Rousseau, and has been since stated repeatedly. It appears that the city is a sort of biologic furnace which in the course of three or four generations pretty thoroughly burns up vitality, and that the addition of country stock is essential for the perpetuation of family life in the city.

General Results.—All these differences coincident with civilization and the development of the city are disturbing the balance of expenditure between the neural and muscular systems. In muscular exercise there is the neural element, but in mental and emotional activity there is not

the muscular. The result is a new balance in the total activity of the body, a different environment with reference to activity from that which the organism is adapted to, or has previously had.

Special Classes.—Let us now note a little more in detail the different classes in the city with reference to their physical activity. The **workers in factories and shops,** handling machinery for approximately ten hours a day, make an immense number of movements of a more or less uniform character. The **clerical classes**—bookkeepers, stenographers, salesmen—have considerable walking to do, handling goods, going on errands, and the like. Most of them do no work that involves deep breathing or quickening of the circulation. Their muscles do not have a physiologic amount of labor from one month's end to another, except the small muscles involved in writing or similar occupations. We find them as a class with sunken chests, small arms, more or less round-shouldered, and with but little physical endurance or muscular strength. The cardiac muscle is not specially vigorous. **Business men** lead lives that are largely sedentary. The burden of their work is done at the desk. Such men are often fat, with protuberant abdomens. They have even less muscular labor to perform than the clerical class. Women who work in factories have already been considered. Women who do **domestic service** have sufficient muscular activity of varied character, and so far as this element is concerned nothing is needed. **Mistresses of households,** while they are about a great deal, do so little work involving activity of the large groups of muscles that these muscles are rarely in a condition of normal vigor. **Manual laborers** in a community are comparatively healthy.

The object of the discussion so far is to show that in civilized communities the environment that has been making during untold ages for the present shape and functions of the human body has so changed that the normal requirements of daily life for muscular activity are insufficient to keep the organism in that condition of vigor necessary to the best health; and hence that to maintain the body in conditions of health and vigor, **conscious attention** to this factor of environment is of increasing necessity.

FUNCTION MAKES STRUCTURE

This, the well-worn formula of the evolutionist, may be applied in two directions. First, it implies that to produce any given effect upon the structure of the organism, we should institute exercises that are calculated to achieve the desired perfection of structure. Secondly,

it implies that except under certain pathologic conditions, the kind of exercise best adapted to produce the balanced and healthful development of the body as a whole or of its parts is, in the main, the kind of exercise for which the part exercised is best adapted.

The first point needs hardly more than the statement. Leaving out of account pathologic cases, if the heart is to be increased in structure we prescribe gradually progressive exercises that make a greater demand on the heart, with the result that it is gradually built up to meet this increased demand. Upon this is founded the special work of Oertel, Schott, and others. If the muscles of the upper extremities seem to be deficient in size, we prescribe exercise that demands the functioning of these muscles, and we expect the function to be the indirect agency that shall produce growth and structure. If we find the muscles of the back of a growing girl flabby and poorly nourished, with the spine in the early stage of scoliosis, the first indication is to increase the power and efficiency of the faulty muscles. This is accomplished by increasing the function of the parts, and the structure rapidly follows the function. This general law applies not only to the development of muscle-tissue, but to other tissues as well. It has been shown that the bones of both horses and men that do work in which power is demanded have a heavier specific gravity and a greater density of structure than the bones of those engaged in less laborious occupations.

The second application of this formula is that **the body as a whole, and each of its parts, is best exercised in accordance with its natural function.** The far-reaching character of this principle is not easily seen at first glance. The upper extremity is obviously adapted for the handling of objects. The great range of movements allowed by the shoulder-joint as contrasted with the hip-joint, the structure of the forearm as compared with the leg, allowing not only flexion and extension, but pronation and supination in the arm, the more delicate structure of the hand, the independence of the phalanges, the more differentiated nerve-supply to the muscular tissue—all point to a difference in function in these two organs: the lower extremity as a whole being adapted for power, the upper extremity for varied action, delicacy, quickness of movement, and the like. It is true that the upper extremity may be trained so that the weight of the body shall be handled by it alone for considerable periods. This is done by performers on the horizontal bar, the German horse, rings, and the trapeze; but it is a departure from the normal function of the arms and results in limitation of the movements at the shoulder-joint, the stiffening of the ligaments of the hand, and general perversion of function. On the other hand, it is possible to train the legs to exer-

cises of great skill and delicacy; jugglers who learn to handle objects with their feet while lying on their backs accomplish this result; but in neither case are the results worth the labor expended. They are not in line with the natural functions of the organs, and the best development of each part of the organism is related to its natural function. Our aim should be not to see what each part can be trained to do, but to get each part into its normal condition. The body can be trained to do and to endure many things that are not only useless, but harmful. Because a man can learn to walk on his hands is no sufficient argument for men to adopt that mode of locomotion; because the shoulder-joint can be made to resemble somewhat the hip-joint is no reason why it should be made to do so; so that, excepting conditions dependent upon pathologic states, it may be safely said as a general proposition that the exercise of the body as a whole, and of its parts in particular, should be related to the natural functions of the part.

Vis naturæ.—With normal heredity and normal environment the individual will develop a balanced organism. The constant tendency of the organism is to develop along suitable lines. Upon the germ plasm is written the law of development of the individual. Environment may hinder or accelerate this development: if it is one-sided or otherwise perverted, the results will be abnormal, but the essential character of the protoplasm cannot be altered. This fact is of supreme importance in the **physical education** of the young. It has been customary to measure the various parts with great exactness, and then to attempt to prescribe exercise that shall meet the specific needs of each part, as shown by its deviation from the average of the species. Theoretic reasoning as well as experience shows that such work is generally useless. What is needed in normal cases is to supply normal conditions of food, rest, exercise, sleep, and the like. That which is a perfectly symmetric body for one person will not be so for another. When the deviations from the average are so marked as to be pathologic, or when there is specific disease that must be combated, the conditions are somewhat different. What are now referred to are the smaller differences, which are entirely normal. For instance, the fact that the left arm is a quarter or even half an inch less in girth than the right arm is not a matter for special consideration. If both arms be given vigorous work, they will become equal not only in measurement but in power as well. This I have repeatedly demonstrated upon both the growing and the full-grown organism. It is commonly said that the girth of the neck and of the flexed upper arm and of the calf should be the same, and some have spent much time in the endeavor to secure such measurements; but more basal than such arti-

ficial conception of symmetry is the standard of development contained in the germ plasm of each person. If vigorous all-round exercises produce such measurements in the individual, they are then the best for that individual. If not, the endeavor to secure them is prejudicial rather than helpful. In subjects of so-called nervous temperament, with long, rather slender bones and small joints, the muscular proportions differ from those in whom opposite conditions obtain, and the attempt by means of artificial standards to force individuals of these two types into the same physical form is most unwise. We may demand similar functions from the bodies of the two, but the proportions of the body will take care of themselves. It is our business to furnish a suitable environment and demand the normal functions. Natural tendencies may then be depended upon to render the structure normal, or at least to give it that type best adapted for the life of the individual.

PHYSIOLOGY OF EXERCISE

The contraction of a single muscle involves three major elements: activity in the **motor center,** a **nerve-current** to the muscle, **contraction** of **muscle-fibers.** Let us note the general effect of exercise in these three divisions.

Effect upon the Muscle-cell.—The contraction of the muscle-substance is accomplished by a mechanism as yet beyond ultimate analysis. Energy is expended. Some of the highly complex cell-constituents are broken down and extruded. The cell at once proceeds to absorb from the surrounding plasma additional food materials, particularly carbohydrates and oxygen. Thus, muscular activity results in the constant change of some of the essential elements of the muscle-cell itself, which is kept in a state of increased efficiency proportionate to its use. Both the number and the size of muscle-cells are increased by exercise. The sarcolemma appears to be slightly increased in strength. The growth in this, the fibrous part of the muscle, is well shown in the toughness of muscles taken from animals that are heavily worked as compared with those that are not so worked, or with the flesh from animals that have never been worked hard; the fibers being coarser and heavier, the tendons thicker and less yielding, the whole muscle firmer.

General Effects of Muscular Exercise

The absorption by the muscle-cells of oxygen and carbohydrates from the blood plasma has immediate and ultimate effects upon the body as a whole. When muscular energy is expended, the blood is altered in constitution. Such blood flowing through the respiratory center in considerable

quantities causes **increased respiratory movements.** All the muscles of respiration are thus brought into immediate and often vigorous action, even the accessory muscles being called on promptly when there is particular need of rapidly augmenting the oxygen supply. The blood circulating through the lungs makes up its oxygen tension, the added activity of respiration changes the air in the lungs, with the result that during exercise the percentage of oxygen in the lungs is greater than usual. The contraction of the muscular fibers squeezes the lymph-vessels and the smaller veins so that blood and lymph are pressed onward toward the heart. This, together with stimulation of the centers governing circulation in the medulla, causes **increased cardiac activity.** The quickening and deepening of respiration also are effective in the aspiration of the thorax. By these various means the circulation of the blood is at once markedly stimulated, and the arteries supplying the muscles exercised are immediately somewhat dilated. We thus have a completely adjusted mechanism for augmenting food-supply and eliminating waste. The muscle-cell eliminates the products of combustion in the form of carbon dioxid and of urea or some of its antecedents. These are carried away by the circulation, which is now accelerated, the carbon dioxid being eliminated by the lungs, the urea by the kidneys. The greater consumption by the cell of carbohydrates and proteids affects the organism in ways that are somewhat analogous to the enlarged need of oxygen, but instead of causing oxygen hunger there is produced **hunger for food.** Through the influence again of the vasomotor system, the whole digestive tract comes eventually into a state of heightened activity, in part owing to the increased blood-supply, but chiefly to direct neural stimulation. The consciousness of hunger is more marked, and gradually the normal individual will be led to eat more food as certainly and as definitely as he is prompted to breathe more air. A third group of activities is due to the **heat** evolved by the rapid combustion in the muscles. This is kept down by the dilatation of the superficial arteries and capillaries which increases surface radiation. At the same time the sweat-glands are influenced through the sympathetic nervous system to operate with more or less vigor, throwing sweat upon the skin. The evaporation of this sweat cools the body, and is a potent factor in preventing the rise of the body-temperature. Thus, through muscular exercise, the **function of respiration, circulation, nutrition, and excretion** are all profoundly affected, and the heat-controlling mechanisms of the skin and sweat-glands are stimulated to greater action.

Special Effects of Muscular Exercise.—Let us now examine somewhat more in detail certain special features of bodily exercise.

Every muscle tends to contract, even during rest. This is due to two causes: the elasticity of muscle-tissue, and a certain amount of stimulation that is constantly being sent to the muscle. The tension is greater when the muscle is healthy and when its proper nerve-center is in normal state, than when other conditions obtain. Again, the strength of this contraction varies directly as the strength of the muscle; thus, when the pectorals are developed out of proportion to the trapezius and other muscles, the normal pull of the pectorals will overbalance the pull of the trapezius and rhomboidei, with the result that the shoulders will be drawn forward. When the flexors of the fingers are developed far more than the extensors, the fingers will hang in a semiflexed position. The tendency of much of the gymnastics of the heavy type performed on gymnastic apparatus is to develop the flexors not only of the arms, but of the trunk, more than the extensors, with the result not only that the hand is nearly contracted when at rest, the elbow hanging partially flexed, but the shoulders are drawn forward, the spine is bent, and the ribs are depressed by the action of the recti and the two obliques. In order to preserve the balance of power between the flexors and extensors of the arms, and particularly of the trunk, it is necessary to give approximately twice as much work to the extensors as to the flexors. Thus, in doing work with the pulley-weight apparatus, a person should spend approximately twice as much time facing the apparatus as with the back to it.

Muscles and ligaments tend to assume the position during rest that they occupy during exercise. If, for instance, the muscles of the forearm are exercised vigorously in a contracted position, as they are in rowing, when the man is through rowing his fingers will stay almost flexed; and if he rows day after day for a good while, only with difficulty can the fingers be wholly extended. The muscles that contract the fingers have overbalanced the extensor muscles, and are holding these fingers in the flexed condition. On the other hand, the back of a coal-heaver is an illustration of muscles that are stretched, and at the same time strong. The coal-heaver has developed a powerful back, but he has used his back in the bent condition, so that while he has great masses of muscle upon his back, it is difficult for him to straighten himself, and after some years of such work he cannot do so at all. The parts have become so accustomed to the bent position that they retain it permanently.

Thus, **the position taken during exercise** is of the greatest importance. If a person takes pulley-weight exercise with the spine in a forward position, the ribs depressed, and the chest flat, that very exercise will

tend to make this position a permanent one; and yet this is exactly the position that uninstructed individuals commonly take in gymnasiums when doing pulley-weight work. Again, work on the parallel bars, particularly the bent-arm work, is usually taken with the spine flexed, and with the ribs in a depressed condition, the pectorals being in active contraction, as are also the muscles of the abdomen. The tendency is to perpetuate in the individual the form held during the exercise. We are all familiar with those who have done a great deal of such parallel bar work, and have observed the flatness of their chests in spite of the large development of the greater pectorals.

The general effects of exercise are in relation to the number of foot-pounds of work performed. By the general effects of exercise are meant the effects upon the heart, lungs, digestive organs, nervous system, and general cell-metabolism. We shall not here consider the effects of extended attention, or concentration of mind; that will come later on. We are now considering merely the general effects of exercise upon the body. I may extend my index-finger as many times as possible, until I am thoroughly exhausted, without producing any great effect upon my heart, lungs, or digestive organs; although I may produce an effect upon my nervous system from the exhaustion that would supervene from excessive work. The exercise of so small a muscle has comparatively little effect upon the great organic functions of the body. The amount of mental effort put into the exercise does not appear to be directly related to the activity of the heart and lungs. If I stoop down and raise myself I am not at all fatigued, but I have done that which has an immediate effect upon the body as a whole. The heart is increased in action from five to twenty beats in the minute, and the breathing is accelerated, even by a single movement of this character; there has been comparatively little nervous, but a great deal of muscular, expenditure. Such an effort might be equal to a hundred foot-pounds of energy, whereas the most vigorous effort of my will might not suffice to perform a hundred foot-pounds of work by the contraction of the small muscle referred to before—the extensor indicis. In seeking, then, the general effects of exercise upon the body, we must exercise those groups of muscles with which it is easiest to perform large amounts of work. These are obviously the great muscular groups of the body—the flexors and extensors of the thigh, and the muscles of the back, abdomen, and shoulders. These five groups include by far the strongest muscles in the body. Upon their exercise we must chiefly depend for effect upon the vital organs. Exercise of the muscles of the forearm and upper arm is somewhat effective; but so much inferior are these muscles in size

and power to the other muscles referred to, that great reliance cannot be placed upon them. When muscles contract, we can foretell to a nicety how much effect there will be upon the heart and lungs, if we know the number of foot-pounds of energy to be expended. This is our most valuable criterion. Because of their greater natural capacity for skill, as well as because of the more showy character of their work, it is common in gymnasiums to find chief attention given to the development of the arm muscles. The fallacy of this is easily seen.

Physiologic Load.—There is a load for each muscle, and for each group of muscles, under which it can do its maximum of work. This we call its physiologic load. It is the load under which the greatest effect can be produced upon the organism. If the element of time is considered, the load must be altered to correspond. There is thus a physiologic load for each muscle for each length of time. It has been demonstrated that muscle will contract more vigorously and effectively when it is pulling a certain load than it will when contracting free; thus, the advantage of working against a weight of some kind. This weight can usually be the weight of the body in some form or another, except in the case of the arms, which are not well adapted to handling the weight of the body. For the arms we use apparatus in order to bring about this contraction under a load; and the longer the exercise is to last, the lighter we make the load. It is not sufficient that we shall contract the upper arm so many times; it must contract under a given load in order to secure the proper physiologic result.

Exercise a Factor in Promoting the Circulation of Fluids in the Body.—In this respect it is second only to the contraction of the heart. In the great muscle-groups of the body the lymph circulation is chiefly carried on by the contraction of the muscles. These press upon the lymph-spaces and urge the lymph on. The circulation of blood, as well as of lymph, in the abdominal organs is accelerated by exercise and by deep breathing. When the diaphragm makes large excursions, the abdominal organs are alternately pressed upon and released. The valves in the large veins are so arranged that the fluids can only go in one direction. Thus, it is clear that the relation of deep breathing to the circulation of blood in these organs is intimate. This indicates the great limitations imposed upon the health of the abdominal organs by anything that restricts the breathing, and one of the reasons why **deep breathing** is so effective in bringing about a state of vigor in the whole organism. Deep breathing seems to increase the freedom with which the return flow of the blood from the head is effected. This perhaps is not a major effect, but it certainly should be reckoned with.

The quantity of oxygen absorbed—that is, taken from the air of the lungs into the blood plasma and into the hemoglobin—varies in proportion to the need of oxygen in the body far more than in proportion to the quantity of air inhaled and exhaled at each breath. One may by deliberate effort breathe with rapidity and amplitude. The result is that the air in the lungs is more free from carbon dioxid than is usual. This, however, will not raise the oxygen absorption in the body. The oxygen tension in the blood plasma remains measurably constant. The way to increase oxygen absorption by the tissues is to do work that increases the breaking-down of oxygen compounds. Thus, there is more demand created for oxygen, deep breathing results, and this deep breathing is effective in the promotion of oxygen absorption. We thus see the fallacy of expecting to rejuvenate the tissues of the body by voluntary deep breathing. Such deep breathing may have useful effect in strengthening the accessory muscles of respiration; or by means of the wide excursions of the diaphragm moving back and forth the abdominal contents and thus affecting the vigor of these organs; but its usefulness is not primarily related to increased absorption of oxygen.

Effort on the part of individual muscles requires the fixation of the thorax and thus increases intrathoracic pressure. This effectively prevents the return of the blood to the veins leading into the thorax, and produces a passive congestion, which is most noticeable in the head. The staring eyeballs of a person making a vigorous effort, lasting a number of seconds, are familiar to all. The filling up of the great veins in the neck and head merely indicates the process that is going on all over the body.

Agitation of the body tends to accelerate intestinal peristalsis and hepatic circulation. This is noticed in the effect that riding a hard-trotting horse has on those of sedentary habits. For this reason running is more effective than bicycling in its effect upon the abdominal organs. Extended movements at the waist are also effective in their relation to the abdominal organs, the three factors being as already mentioned: increased peristalsis, increased circulation of contained liquids, stimulation by means of the wide excursions of the diaphragm.

Position of the Thorax and Curve of the Spine during Exercise.—When the dorsal region of the spine is flexed, the ribs are depressed, the chest is flat and the amount of space for the heart and lungs is less than when the opposite conditions obtain; the difference in the anteroposterior diameter in the two positions being often as much as three-fourths of an inch. When the trunk is thus cramped, the heart becomes embarrassed and irregular during severe exercise far more quickly than when the ribs

and spine are both extended. This may be due primarily to the interference with respiration and circulation. Another point that has been demonstrated clinically is that the flexed position of the spine and the depressed condition of the ribs are associated with a less active process of digestion and feebler peristaltic activity. It is thus of fundamental importance, when we wish to secure the general effects of exercise upon the body, that such exercise be taken with the spine in the erect position, and the ribs well everted. The tendency during much of exercise, unless there is special instruction, is to stand or sit in the flexed position. This should not be allowed.

NEUROLOGIC CONSIDERATIONS

Automatic and Voluntary Exercises.—Movements that are made with regularity and constant force are soon taken in charge by the lower neural centers. They are directed by the hind-brain, or possibly by the upper centers in the spinal cord. This frees not only the upper motor centers, but the seat of consciousness as well. Fatigue is more closely related to exhaustion of these upper motor centers, or even of the consciousness, than to exhaustion of the muscle-cell. Movements made automatically have far more effect upon the body in proportion to the amount of fatigue they produce than have those exercises demanding constant attention. The comparative fatigue of walking upon a smooth road and upon railroad ties placed at uneven distances is a familiar example of this principle. The automatic nerve apparatus does not become fatigued readily. The general effect upon the body, and the effects upon the muscle-cells, the digestive organs, the organs of circulation and respiration, etc., are, however, not affected by the source of the neural stimulus to muscular contraction—they are the same whether the exercises be automatic or voluntary. A typical example of a rhythmic exercise is bicycling at a moderate gait over a reasonably smooth road after one has become thoroughly familiar with riding. The somatic effect of the exercise is the same as when one is riding in a narrow track, but in the latter case constant attention is demanded and fatigue rapidly supervenes. Thus, physicians who have to do with individuals who are, as a whole, in need of muscular exercise, but who are already partially exhausted neurally, often have occasion to make large use of rhythmic exercises.

The relation between neural and muscular expenditure is not constant. Every increase in rapidity of movement calls for proportionally more neural energy than muscular energy. This is well illustrated by a

person starting in the hundred-yard dash: the waiting with attention strained for the pistol-shot, and then the immense rapidity of the start, demand more neural energy many times over than does getting up the same degree of speed more slowly. It also demands, of course, more muscular energy to overcome inertia, but the neural demands are far greater in proportion than are the muscular demands. One starting a number of times in succession may become so fatigued that the hands will tremble violently when the muscles are still comparatively fresh. This is exceedingly important in the application of so-called **calisthenic drills.** When one wishes the individual to follow the commands of the leader the instant they are given, a far higher degree of attention is demanded than when he may follow more slowly. A teacher of gymnastics who is anxious that his class shall present a creditable appearance will constantly insist that the commands shall be followed instantly. This is unfortunate for the pupil who already has the least tendency to neural fatigue. It is harder, too, on adults or the middle-aged than on young persons, because reaction-time is slower in the former classes. After a drill or a set of exercises has been memorized so perfectly that conscious attention is no longer needed, the conditions, of course, have changed; but pupils in the gymnasium do not usually reach this condition. For this reason, from the standpoint of the general effects of exercise, it is important that there shall not be great haste in the following of commands, and indeed it is preferable that there be but **few commands,** but that the work be done largely by **imitation;** that being the more direct, simple, and neurally least expensive, form of instruction. In recommending patients to take exercise in gymnasiums, great care should be taken as to the character of the teaching with reference to these points. When the patient is primarily deficient in muscular strength or digestive ability, but has no tendency toward neurasthenia, the indications do not preclude the utilization of exercises made upon command. But in the far more common cases among urban residents, in which there is a tendency to nervous exhaustion, exercises of this character are usually, if not always, injurious. I have seen many patients injured rather than benefited by them.

Moderate and Excessive Exercise.—Another consideration in the comparison of neural and muscular expenditure involved in a given exercise relates to the effect of **moderate** as compared with **extreme activity.** The law will not hold in regard to extremely light loads; but leaving the latter out of consideration, the larger the muscular load, the greater the comparative nervous effort in the expenditure involved. It is true that even the mechanical effect of lifting 25 pounds one foot twice,

is not quite the same as that of lifting 50 pounds one foot once, and hence the effects upon the muscle-cells and the viscera differ in these two cases. But there is a still greater difference in the effects upon the nervous system. More neural energy is demanded to cause the muscles to contract once with the 50-pound load than to contract twice with the 25-pound load. This matter is therefore important with reference to the same class of persons mentioned under the preceding head. They should be given moderately heavy work, but of sufficient duration to accomplish the result, rather than be made to accomplish results with a few large efforts. A common and useful test is to notice the hands when held with fingers extended and free from each other, the arm being held away from the body. If the fingers are trembling, there has probably been too much effort. One may do considerable work, in small doses, without producing this effect; but even a moderate quantity of work in one or two large doses will quickly induce it, and it is then often followed by sleeplessness and indigestion.

Of how much importance is physical exercise in the development of the brain? From one-third to one-half of the brain surface is concerned in making muscles contract, definite areas being in relation with definite muscles or groups of muscles; but this does not prevent these parts of the brain from being used in other ways also. Although we know but little about the function of the different portions of the brain, we do know that it is necessary to have muscular exercise of any group of muscles, if the corresponding nerve-center is to be developed. Careful examinations have been made of the brains of subjects who had very early lost a limb, and it has been shown that the brain-centers normally active in the management of the muscles of the amputated limb were never developed. Hence, if the full development of the entire motor area of the brain is to be achieved, the muscular functions of the body must be exercised to their full capacity. Not merely must each muscle become powerful, but the faculties of co-ordination and control must be developed. These appear to be even more closely related with the finer organization of the nerve-structure, than is the exhibition of power.

There are some nerve-centers having to do with muscular contraction that ripen, without ever having the subordinate muscles in active operation; for instance, the respiratory center. The new-born babe finds its respiratory apparatus, neural and muscular, in perfect condition for operation. It may be that when a sufficient number of thousands of years have passed, the whole brain will be in the condition in which the respiratory and a few of the other brain-centers are now. Physical education then will be *nil*, and we shall look to physical exer-

cise merely as a hygienic measure to insure health, all the neuromuscular mechanisms ripening and coming into perfect function through the inheritance from countless generations of ancestors. At the present day, however, varied muscular exercise is absolutely indispensable in the development of the brain; and upon the right development of the brain is dependent the large bulk of our psychic activities.

Fatigue.—The subject of fatigue must interest all physical trainers. Muscular fatigue, as we usually speak of it, is our consciousness of the partial exhaustion of the motor centers controlling the muscles that have been worked. In ordinary life we do not often experience genuine fatigue of the muscle-cell; but this is not the only form of fatigue. When certain brain-centers are fatigued, we can then turn to other centers, centers concerned with other muscular groups, and operate them. When these in turn are fatigued, we can call on still others; but long before there comes the exhaustion of the motor elements for all the muscles, there is another fatigue that supervenes, so that muscles that have not been concerned in the activity cannot be operated with either power or accuracy. This is not due merely to the presence in the circulation of the 'fatigue stuffs' produced by the exhausted muscles or by their nerve-centers, although this is undoubtedly an element. If we call this **will fatigue,** it then becomes of importance to find the point in the training of the muscular system at which the maximum of benefit to the physical organism can be secured without appreciably lessening the power of the individual as shown by his ability to will. It is a matter of common observation that there is no form of exertion so exhausting as emotional activity. Excitement and worry are prime factors in the production of exhaustion. We shall consider later on—in the detailed study of various exercises—their emotional aspect; thus, the difference in effect of an exercise such as sparring when it is done face to face with an opponent, and when the movements are done alone. We shall leave the consideration of this point for treatment at that time.

Co-operation among Contiguous Nerve-centers.—One of the most potent arguments for a large amount of exercise during young manhood is that **nerve-centers may draw power from neighboring nerve-centers.** Conversely, it has been shown that exhaustion of contiguous motor areas may come through the efforts of a single center so small as that governing the flexor indicis, if this activity be kept up long enough. All are familiar with the fact that extreme exhaustion in one line incapacitates us in others. This may be partially explained on the ground of fatigue stuffs being poured into the blood-current; but the far more rapid recovery of animals when these fatigue stuffs have been produced

outside the body and then injected than when they have been produced in the body, would be in line with the clinical observation already mentioned. Thus, we see the great importance of the thorough development of the motor area of the brain. Men of intellectual ability may not have well-developed muscular systems; but it is rather unusual to find men of extended intellectual capacity for work during many years who have not during adolescence engaged in vigorous and extended exercise. The motor brain seems to be a sort of battery furnishing power for intellectual labor; but it furnishes endurance rather than force. The natural interests of young men in exercises of an extreme character would indicate to us that there is some organic need of such exercise during these years, for we cannot think of such instincts having arisen spontaneously; they must have arisen by natural selection and therefore meet a demand in the individual.

The **kind of exercise** demanded during the succeeding years of the life of an individual must be related to his changing characteristics throughout these years. In recommending exercise of the neuromuscular apparatus from the standpoint of motor education, we must first ask the question: What is the condition of this apparatus? We know that the brain, spinal cord, and muscles of the new-born infant are in a far different condition from those of the adult. We know that its capacity for muscular activity not only differs from that of the adult in power, but even more so in control. The comparatively recent efforts of the neurologists have, however, given us ample ground for procedure; although, hitherto, the physical trainers have taken but small notice of this most important series of facts.

The general **order of development** of the motor centers seems to be as follows: first, are developed those that have to do with functions already reasonably perfect at birth—respiration, circulation, sucking, crying, and other movements that need no particular training. The motor centers for the control of the skeletal muscles develop in the order of their distance from the trunk; thus, shoulder before elbow, elbow before wrist, wrist before fingers. There is some overlapping, but in the main the progression is of this character. At birth the child has perfect grasping movements, but the independent control of the fingers comes comparatively late. It is not done with readiness until after seven in most children. This order of development is merely that shown in general by embryologic investigations. Those movements that are racially the most elementary or the most early, come first in the individual. The interest that the child shows in special forms of activity is an excellent guide to the order of development of the motor activities.

This order of development of the nervous system is important with reference to **educational gymnastics,** because otherwise they are abnormal. Nothing but disaster can be expected if we attempt to force motor education out of its natural order. The education of any part is best done when that part is ripening. If this is accomplished, the part may be further perfected at any time during later life. If it is not accomplished, the part can never be made to reach its highest development by later education. The development of the motor areas for the trunk takes place during the first two or three years of life. The arms and legs are pretty well under control at the age of five or six. The interest of boys in marbles; in all forms of machinery; in throwing, shooting and similar exercises, indicates the growth of the finer motor areas between the years of seven and twelve. The interest of girls during the same years in sewing and playing with dolls, which involve the finer activities, is an indication in a similar direction. The activity of the speech center begins early, but has its greater development within the first three or four years. When special attention is given to specific exercises demanding skill in distal groups of muscles before the more proximal muscles have been trained, we often find neuroses supervening. Dr. Hartwell has made extended studies in regard to stammering and stuttering in this relation. In former days those destined for a musical career were put at their special work—for instance, on the violin—at as early an age as four; but experience has shown that such education ought not to be begun until the child is seven or eight years of age. This experience is in accord with the neurologic fact just mentioned, that the motor centers for the fingers and wrist begin to acquire special activity after the age of eight years. The selection of voluntary exercises for the development of this neuromuscular mechanism ought, then, to be practically completed before the boy or girl reaches the teens, for the apparatus is pretty well developed by that time. Gymnastics, so called, affect chiefly the larger groups of muscles. The finer groups concerned in independent finger movements, activities of the larynx, facial and tongue movements, are not trained by gymnastics; their exercise must of necessity come in other ways. The playing of games of children, as we shall see later on, involves the discipline of these motor centers; thus, gymnastics to be of the greatest educational value ought to come during the first three or four years, or at least the first six or seven years, of the child's life; but for many reasons it is obviously absurd to attempt to have children during these years do gymnastic work. We are thus driven to the conclusion that the primary object of gymnastic exercises, such as are prevalent in our gymnasiums, cannot be

solely that of neuromuscular education, and that for this process of education we must depend upon other agencies than voluntary gymnasium work.

Muscular Exercise and Cerebral Hygiene.—As we have seen, the absorption of oxygen by the blood plasma and the digestion of foods are both related to muscular activity. The constitution of the blood, then, is related definitely to muscular activity. The power of the heart and the healthy tone of the arterial system are both related to the quantity of muscular exercise. These points have much to do with normal, healthy cerebral activity. A vigorous heart, a respiratory system that performs its functions effectively, digestive organs that keep the blood rich in tissue-forming and energy-expending elements, form the material basis for cerebral health.

Muscular Exercise and Vasomotor Hygiene.—The vasomotor system has been called the hub around which organic life revolves. The control of the blood-supply of the body appears to govern not only activity, but emotion as well. The vasomotor system appears to be the basis of the emotional nature, bearing somewhat the same relation to emotions that the brain does to intellect. This is in accord with the observed facts that insanities are prone to begin with perverted feelings, and that the wild delusions of religious devotees, hallucinations, and the like are more frequently found among those who have not had vigorous muscular exercise than among those that have had such exercise. A balanced activity of the vasomotor system is secured only when it is called on for its normal functions in connection with the regulation of the blood-flow to muscles in vigorous use. In those who take but little muscular exercise the vasomotor system is far more liable to irregularities. One who does mental work and neglects to take exercise is likely to have cold hands and feet. Sane notions in regard to daily activities are thus related to a vigorous functioning and balance of the vasomotor system.

Muscular contraction appears to be closely related to the genesis of many forms of **psychic activity.** Not only do the vasomotor and muscular systems express the thinking, feeling, and willing of the individual, but the muscular apparatus itself appears to be a fundamental part of the apparatus for these psychic states. Without the muscular system, the necessary material for psychic activity cannot be provided. The three processes of **thinking, feeling,** and **willing** are more or less closely connected with a rehearsal, both neural and muscular, of the acts by which the original material for the mental process came in. As G. Stanley Hall puts it: "We think in terms of muscular action, more or less remote, and all the parts that were concerned in the original activities

are more or less active in the thought. Nerve currents are constantly going to the muscles and coming from sense organs, all being a part of the thinking apparatus." If this be true, the fulness of the neuromuscular experiences during early life would appear to be related to the opportunity for later psychic range. This is borne out by the fact that both in animals and in men the scale of intelligence corresponds to the number of possible muscular co-ordinations. The more complicated the neuromuscular apparatus, the higher the intelligence. It is true that the individual profits mainly by racial inheritance of all these complicated mechanisms; but even so we may expect to find that the individuals who live a life of psychic activity have been, on the whole, those who during early life have had a rich and full experience of muscular co-ordinations. It is not difficult to perform a few simple experiments to illustrate this point. If one repeats the alphabet as rapidly as possible, it takes about four seconds. If, now, one thinks the repetition of the alphabet, but without making any muscular movements, it takes approximately the same length of time. During the severe effort to repeat as rapidly as possible one becomes conscious that the mechanism involved is the same as when repetition is actually done. One can feel the latent movement—if I may use the expression—of the larynx, lips, and tongue. To think the alphabet in terms of writing, takes about the same length of time that it actually does to write it. Thus, the speed of muscular movements is related definitely to the speed of our thinking; and this rule, moreover, is one of those that "work both ways." It is not, however, merely in reference to the intellect that the muscular system is important. The sensibilities, or feelings, or emotions are definitely related both to muscular and to visceral states. We are accustomed to think of the expression of the body, particularly the expression of the face, as merely the outward manifestation of the inward state. The modern psychology, however, is telling us that this muscular contraction is a necessary part of the feeling itself, and that when the muscular expression of the feeling can be inhibited, the feeling itself is not the same. Rage is not rage until it expresses itself in muscular action of some form. It may be merely in the stiffening of the whole body, the clinching of the hands, or the forcible compression of the jaws. When we come to the regal faculty, the will, modern psychology again asserts that will must express itself in terms of muscular activity, and that power of the will in its origin bears a relation to firmness of muscle, to power of muscular contraction.

SPECIALIZATION

One of the natural tendencies of boys, girls, and young men is to specialize in certain forms of interesting muscular activity rather than to take exercise that symmetrically develops the whole body. This is perhaps best shown by the college athlete, who not only specializes in baseball but even in a single position on the nine; or he may specialize in pole-vaulting, throwing the hammer, running the mile, or any other of the numerous athletic events. In the gymnasium he may specialize in any single group of muscular performances, although these are not so attractive to the average man. There has been far more condemnation of such specialization, together with pointing out of its evil results, than there has been critical study of its nature and advantages. In the light of evolution it is hardly to be supposed that such general interest should have arisen without there being some useful element in it. The argument relative to the place of specialization in physical training can only be constructed upon the general place of specialization in evolution. Specialization is at the root of all evolution. It is only when the early forms of animal and vegetable life begin to set apart cells for special activity that they begin to rise in the scale of efficiency and intelligence. Certain groups of cells that have been specially developed for the performance of certain actions perform these actions far more efficiently than would otherwise be possible. This is to the advantage of the organism as a whole. For this reason we find a constantly increasing specialization going on in the human body. The various tissues are made up of cells that have become so highly differentiated from the elementary form, which has been most faithfully preserved by the amœba, that it is with difficulty they are recognized as its descendants; but all of them are merely emphasizing certain functions that were common to the original cells. This is no less true of the contractile muscle-cells than of the co-ordinating brain-cells, or the connective-tissue cells. Thus, the whole development of the individual has been related to specialization. This holds not only with reference to the body, but with reference to the development of intelligence and feeling. The individual as a whole also tends to specialize. It has been the common practice among physical trainers to endeavor to overcome this natural tendency toward specialization. It has been said that the left arm should be trained to be as strong and as skilful in every way as is the right arm. The practice that has been given to the perfecting of the right arm in penmanship, in playing the violin, in working with machinery, and in all directions that demand skill, must now be divided by two, in order

that the left arm shall be as well trained as is the right. But even this would not accomplish its end, because in most persons the neural apparatus governing the left side of the body does not have the capacity of the right-hand side for finer organization. The ages of evolution have brought to man as compared with woman special ability for throwing. I have repeatedly endeavored to train the left side of the body to throw a ball as readily as does the right hand; but even with the best training the ordinary man will still throw with his left hand in the same way that a woman does with her right hand. But, even if we should succeed in the endeavor to perfect the left hand correspondingly to the right, what would be the gain? It would be at a large cost of skill on the part of the right hand. The individual as a whole would not be more healthy or more efficient. He would have two members both able to do the same thing, and yet rarely has he need for but one of them at a time. This illustration must suffice to indicate some of the limitations of the usefulness of all-round training.

The Limits of Specialization.—The limit of specialization in the cells of the body is easily seen. The nutritive ability of the cell must never be interfered with. Any other function or every other function may be altered or largely lost through specialization; but the ability to convert inert matter into proper cell-substance must be retained by every cell that continues to live, and the highest degree of specialization is intimately concerned with this fundamental organic requirement for life. We find this same fundamental organic need conserved in the specialization of the individual as a whole. Any degree of specialization that does not violate this fundamental condition of nutrition, does not seem to be at variance with the best needs of the organism as a whole.

In what ways may specialization in athletics or gymnastics interfere with this fundamental, nutritive ability of the organism? It may interfere with the respiration, so that the blood is not kept free from carbon dioxid, and the tissues of the body rapidly degenerate because not supplied sufficiently with oxygen. Thus, specialization which leads to the breathing of bad air, or to faulty positions of the thorax, violates our fundamental condition. Specialization that interferes with the circulation by producing hypertrophy or irregular action of the heart, such as we find when that organ is compelled to work under pressure, likewise violates our fundamental condition. When the energy of the system is drafted off to such an extent through muscular channels that the more fundamental centers, which have to do with organic life, are deficient in power, a condition of asthenia supervenes that is not to be tolerated. This we often find in individuals who have been overtrained. But when

these fundamental conditions are conserved, when the specialization does not interfere with respiration, circulation, digestion, or the control of the organic life through the nervous system, it is not only harmless but eminently desirable.

Somatic Harmony.—Bodily symmetry is not so desirable as **bodily harmony.** The body is symmetrical when the two halves are precisely alike in form and function. This we never find; even the two sides of the face are different; the two sides of the brain are different; the limbs are never precisely alike, and in function they vary even more than they do in structure. The most perfect statues are non-symmetrical. Figures of faces in which the two sides are made exactly alike appear to be lifeless. Differentiation even here has its fundamental significance. **Harmony** exists when the different parts are so related to one another as to produce a whole in which each part is exactly adapted to perfect co-operation with every other part. This is the highest ideal.

If one attempts to judge any form of athletics with reference to this standard, one must ask, first, Does it violate any of the fundamental conditions of organic life? or, to put the question positively and more fairly, Does it favor the fundamental conditions, the fundamental necessities of respiration, circulation, nutrition, and nerve action? If it favors these, it is useful from the physical standpoint. If at the same time, it interests the individual, it is probably useful from a psychic standpoint. It is a matter of comparative indifference that a man should always jump from the left foot, or that he should use his tennis racket with the right hand, or that he should always do the wolf vault to the right and the flank vault to the left. These activities do not interfere with the organic necessities of life, and they do favor the contraction and relaxation of muscles which we have seen to be associated with healthful living. Exercises that do interfere with the somatic life must be avoided, as has been already pointed out. To make the left arm equal in measurements to the right may not even please the esthetic sense, it certainly is but little related to health and vigor; but to put the thorax in that condition in which the heart and lungs shall operate most freely is a matter of the greatest importance. To keep the spine in that position in which the abdominal organs shall all be maintained in normal site and relation is also of great concern, and yet in past years we have given far more attention to the mere matter of equalizing muscular measurements or muscular strengths, and but secondary attention to the larger matters which are related to the somatic life of the individual.

To state the case concretely: A man may specialize in any form of gymnastics or athletics that he pleases, so long as a judicious balance is

maintained between the various nutritive functions of the body. Good respiration, good circulation, good digestion, healthy but not extreme nervous activity, are the desiderata, and will be considered more in detail later on. To illustrate now by undesirable specialization: we should prohibit exclusive specialization in such exercises as the hundred-yard dash, pole-vaulting, running high or running broad jumping; and in work on parallel bar, horizontal bar, and like forms of activity. The former group of exercises calls for too much nervous expenditure, and not enough of steady exercise; while the latter calls for development of the shoulders at the expense of the parts below the hips, and fails to provide sufficient respiratory exercise, the result being a lack of development of both circulatory and respiratory systems.

Competition.—One of the evils most commonly decried in connection with athletics is excess in competition. A judicious balance must be observed here. When the individual is suffering from any form of nervous exhaustion, competition is unqualifiedly bad; for it increases the nervous expenditure in ways already indicated, but to a heightened extent. When it is for other than neural purposes that the individual is to exercise, competition may form a stimulus that will maintain interest for long periods in work which otherwise would be dropped. Thus, sparring or bowling can sometimes be relied on for exercise when other equally valuable forms are not sufficiently attractive to the individual to induce him to persevere in them. A moderate degree of competition will help rather than hinder the ordinary man. The extreme competitions such as are seen in intercollegiate contests, cannot be defended upon physiologic grounds; for overexertion is far more common in such connection than in any other related to physical training.

Dosage.—Only general considerations need to be discussed. Exercise is too severe for the best results to be achieved if the performer does not completely recover from the incident fatigue during the subsequent night. The more nearly normal and vigorous the condition of the patient, the larger and more infrequent may be the dosage; the less habituated to exercise, the smaller and the more frequent the dose.

It is my practice, when working for the **general vigor** of a patient who is entirely under my direction, to divide the daily exercise into five or six doses. Each period has exercise of some particular type, although all are related to the requirement of general somatic vigor rather than to any technical skill. On rising, fifteen minutes of **deep breathing exercises** are often taken. The patient lies flat on the floor and breathes as deeply as possible ten times, then rests ten seconds. This is repeated four or five times. Then with each inhalation the arms are raised to a

line through the shoulders. This tends to help the lateral expansion of the chest (Fig. 1). The same number of movements is carried out as in the former case. After this the arms are raised vertically, which assists inspiration, and, as before, the movements are repeated four, five, or six times (Fig. 2). The arm movements give the variety necessary to avoid tedium. The total effect of such a group of exercises is considerable, and unless the patient is already vigorous, his muscles will be rendered sore. One should ordinarily begin with a quarter of

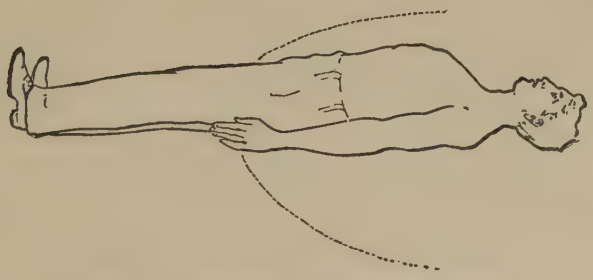


FIG. 1.—EXERCISE TO WIDEN THE CHEST.

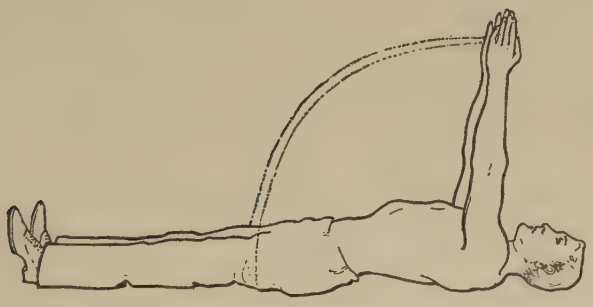


FIG. 2.—EXERCISE TO DEEPEN THE CHEST.

this amount, or even less, and by adding a few exercises each day, work up to the full dose in the course of two weeks. During these movements the patient has vigorously exercised the chief muscles of the trunk, and has definitely stimulated the circulation through all the abdominal organs. At first he will very probably be rendered dizzy. He should work more slowly under these conditions, and a few days will remove the difficulty.

The object of the supine position is to extend the spine, as this favors the expansion of the thorax. The muscles that hold the trunk erect

are also freed from activity, and this also allows increased mobility of the ribs.

At about ten in the morning a series of short fifteen-second, **slow runs,** each run followed by absolute rest, will steadily increase the general strength. In the beginning of such exercise great care must be taken that the heart is not overtaxed. This exercise should be followed by a bath and rest. In the afternoon a long, slow **bicycle ride,** or a game of **golf,** is useful. The doses in running may be steadily increased till three or four miles are covered daily at a steady dog-trot.

The general principle consists in beginning well within the ability of the patient, and by steadily increasing, small doses, at frequent intervals, to train up the whole organism to greater power. This general principle can be adapted to the daily requirements of life, as to business, meals, etc. A routine of **gymnasium exercise** with pulley-weight or other apparatus may well take the place of one period of exercise, although exercise out-of-doors is generally more useful than work indoors.

Often patients wish work of a vigorous type prescribed that will enable them to do all they can in a few moments. The evils of this are that the neural expenditure will usually exceed the muscular; sufficient time is not taken to allow the thorough flushing of the parts with fresh lymph, and the immense benefit of long-continued forced or full breathing is lost. In such cases the individual has merely added to his daily work a certain amount of muscular labor. In all cases in which bodily health and vigor are sought this is a dangerous experiment, and will probably result in still further reducing the stock of vitality. It must be remembered that muscular labor, like all other forms of exertion, is expensive, not recuperative, of energy. Muscular exercise is useful, then, only when the organism has both time and power to rebuild the tissue broken down by it. To add muscular exercise to the daily routine of one already overworking is bad therapeutics. In my own experience it has resulted in hastening the oncoming of the general disability which it was intended to prevent.

In order, then, for muscular exercise to be useful in the case of overworked persons, the following conditions must be fulfilled:

1. **Sufficient diminution of other work,** so that the organism is free to devote its energy to the constructive processes that should follow exercise.

2. **The adaptation of the quantity of the exercise** to the recuperative powers of the individual. This will be found to be a constantly increasing quantity.

CHAPTER II

MATERIA GYMNASTICA; SPORTS AND GAMES; SYSTEMS OF GYMNASTICS

Walking and Running; Calisthenics; Pulley-weight Exercises; Heavy Gymnastic Apparatus Exercises; Track and Field Athletics; Athletic Games; Wrestling, Boxing, and Fencing; Bicycling; Golf; Horseback-riding; Bowling; Rowing. Relation of Physical Exercise to Age and Sex. Baseball, Cricket, Hockey, Shinney, Basket-ball, and Football. Characteristics of Hygienic Gymnastics: School Gymnastics. Training Medically Considered: 1. *Condition;* 2. *Habit;* 3. *Strength;* 4. *Endurance. Systems of Gymnastics: German Gymnastics; Swedish Gymnastics; English Physical Exercises; Delsarte; Sargent; Emerson; Young Men's Christian Associations.*

Let us now examine briefly the characteristics of the chief forms of general muscular exercise available for ordinary use. The following classification may serve for practical purposes, although open to theoretic objections:

1. **Walking and running.**
2. **Calisthenic exercises**—Indian clubs, dumb-bells, wands.
3. **Pulley-weight exercises.**
4. **Heavy gymnastic apparatus exercises.**
5. **Track and field athletics.**
6. **Athletic games.**
7. **Wrestling, boxing, fencing.**
8. **Bicycling.**
9. **Golf, horseback-riding, bowling, rowing.**

1. Walking and Running

In many gymnasiums formal marching is much affected. In order that the command may be obeyed promptly, close attention is necessary, and although in the course of time obedience becomes automatic, this condition is rarely reached in the ordinary gymnasium. Whenever great precision is demanded, particularly when the commands are to be executed with absolute uniformity, close attention to the orders is necessary.

Hence, as the chief effects of this exercise are neural, it should not be indulged in by patients who are nervously overworked. Simple marching without complicated commands or movements, especially without rapid movements, appears to be unobjectionable from the physiologic, as well as from the psychologic, viewpoint.

Walking is the form of exercise most generally utilized. The effects vary according to speed, duration, and the character of the ground passed over. When the walk is not too rapid for the natural swing of the leg to bring the foot forward at the completion of each step, it is a very moderate exercise. The support of the pelvis upon the legs in alternation is an entirely automatic process; cardiac activity is somewhat, but not greatly accelerated; and the respiration is quickened in proportion to the energy expended. The objection commonly raised against walking as a general exercise is that the arms are not used, and that the muscles of the trunk receive no exercise. During rapid walking, on the other hand, the arms are used continuously; at each stride the pelvis is slightly rotated in order to lengthen the stride; the psoas magnus and the long head of the rectus femoris are called into active operation in pulling the thigh forward, while the action of the same muscles is needed to pull the leg forward, particularly at the end of the step. The general discussion under the head of specialization has shown that exercise of all the muscles of the body is not indispensable, but that the important element is the exercise of large groups of muscles. This is accomplished to a large extent by walking, particularly by walking as rapidly as four miles in the hour. When much exercise at this rate seems inadvisable, the same result can be attained by interrupting the walk with frequent rests. This point has been discussed under the head of dosage.

The agitation of the body at every step tends directly to stimulate the functions of all the abdominal organs. In this respect, walking far excels bicycling, in which the body is relatively motionless being supported on the tuberosities of the ischium. When the patient can utilize the advantages of a hill, walking can be made even more effective than on the level. There is no better or quicker way of modifying the great organic functions of respiration, circulation, and digestion than by walking up a grade. This should be done with frequent rests in order to prevent embarrassment of the cardiac or pulmonary systems; but for reasons already discussed under dosage it is important that the exercise be sufficient to call for steady, conscious effort.

The effects of **running** differ from those of walking somewhat in kind, but even more in degree. In running at any ordinary rate of

speed the leg does not have to be pulled forward at each stride; and, on the other hand, the up-and-down motion of the body is greater in running than in walking; thus, the effect upon the abdominal organs is greater, the energy expended is greater, and the effect upon the general system is more marked. The increased activity of the diaphragm also stimulates the circulation of blood in the abdominal organs. Running should not be pursued to the point of circulatory or respiratory embarrassment, not only because of the effect upon these organs themselves, but because at this point great effort of the will is necessary to force the individual to continue; it is thus neurally exhausting. The maximum of general effect is secured by a series of short runs with complete rest between, rather than by walking slowly for a long distance. **Rapid running** so quickly exhausts the organism as to be but little suited for general exercise.

Alternate slow running and walking meets so many of the conditions of general exercise, both negative and positive, that I am confident it will have a large place in the future as it has had in the past in general exercise. It is not of prime necessity that the muscles of the arms be greatly exercised. Slow walking with running brings into play the general activities of the body in an excellent way. In gymnasiums having no running track it is possible to have a large number running on the gymnasium floor by means of what is called 'maze running.'

2. Calisthenics

Although it is convenient to classify together the different forms of calisthenics, they vary much in respect to each other. The primary consideration is in regard to the movement of the trunk. If the legs and body remain stationary, the apparatus and arms alone are moved. The exercise in this case is then generally of a moderate character, and dependent more upon skill than upon strength. On the other hand, when the whole body is moved, the exercise acquires a far more vigorous character, although it may still retain its characteristics in regard to the demand of skill. When the body remains stationary, and in each hand is a light wooden dumb-bell or Indian club, the muscular exercise is insignificant. If the movements are complicated and follow each other with speed, the neural expenditure is large. Those forms of exercise which one is most likely to see in girls' schools are often of a beautiful character, done with grace and precision, but are little adapted for the purposes of hygienic exercise or the stimulation of the general functions of the body. They depend more upon memory, upon skill,

upon instant attention, than upon muscular power. When, however, the body is swayed or swung at each movement, there is added to the slight weight of the apparatus the weight of the whole body. When the floor is touched with the dumb-bells at every fourth movement, no matter what the other movements may be, it means that the weight of the body must be raised approximately 18 inches, which implies a considerable degree of muscular labor, and therefore secures the general effects of exercise.

Exercises with calisthenic apparatus may be difficult, first, because of the muscular effort demanded; second, because of the accuracy with which the movements must be executed; third, because of the demands made on the attention and on the memory. It is therefore difficult to pass on the value of calisthenics as a whole. When the desideratum is the general effect of exercise upon the individual, the drill should primarily call for exertion of the large groups of muscles of the legs and trunk, and not primarily for either accuracy or memory or attention. In prescribing exercise and in recommending a course of gymnastics this point should be kept clearly in mind, for serious nervous collapse has often been accelerated by means of exercise the primary effects of which were not muscular but neural. Calisthenic exercises prepared for exhibition purposes must almost of necessity be of this latter type; for they are more beautiful, and appeal to the public mind in a way that the more vigorous but less accurately executed movements of a larger type cannot. The movements should be performed by the leader and then imitated by the class rather than done to command, when it is desired to increase the muscular and decrease the neural expenditure. When calisthenic drills have to be memorized, it is again unfortunate for the individual who wishes to escape neural expenditure. I have seen prescribed for a group of young ladies calisthenic exercises that took twenty-three minutes to execute. These movements were done to count, each person keeping the count in her own mind. After a certain number of counts each movement was changed without any command from the leader, each pupil depending upon her own memory to execute the proper movement. Thus, to the comparatively insignificant amount of muscular exercise demanded by the particular drill in question, there was added a somewhat complicated intellectual operation, which is exactly what is to be avoided. The general effects of exercise are to be attained by calisthenic drills only when the great muscles of the back and thighs and of the shoulders are brought constantly and vigorously into action.

In **Indian club** work, when the clubs are light and swung without

movement of the body, there is little effect upon the organism as a whole. Swinging **heavy Indian clubs,** however, that cannot be handled by the small muscular group of the hand and forearm, is accomplished by the larger groups of the trunk and shoulder, the hand and wrist in this case being merely used as prehensile organs. Exercise with clubs of a heavy character cannot, of course, be so complicated as it can be when the clubs

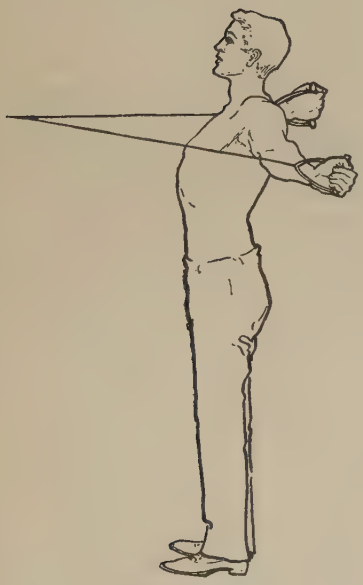


FIG. 3.—EXERCISE FOR DORSAL MUSCLES.

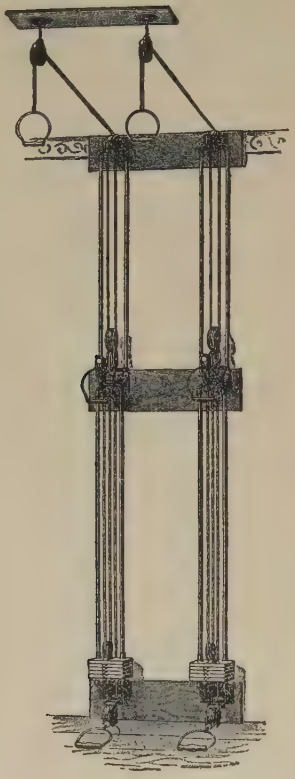


FIG. 4.—PULLEY WEIGHT.

are light; thus, we increase the muscular and decrease the neural effect by such a change. Hence, work with heavy Indian clubs has more general effect upon the body than work with light clubs.

3. Pulley-weight Exercises

There is a large class of gymnastic machines the central element of which is a weight attached to a rope that passes over a pulley. To the

distal end of the rope is affixed a handle or some other means of attachment to the individual. The weights are usually variable, depending upon the load that it is desired to give to the muscle and the size of the muscular group to be exercised. The general object of all pulley-weight exercises is to isolate **special groups of muscles.** This end is largely, although not entirely attained. The so-called **Zander machines** used most extensively in Sweden accomplish this end more perfectly than any others; but they are used so exclusively in connection with medical

FIG. 5.—EXERCISE FOR SHOULDER MUSCLES.

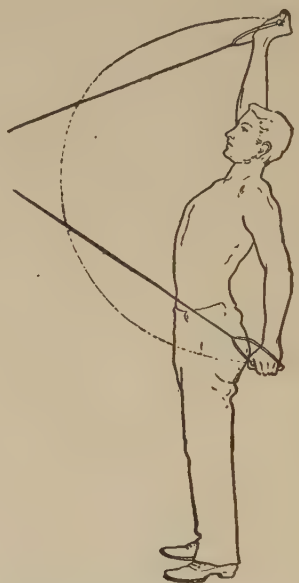


FIG. 6.—ALTERNATE ARM-EXERCISE.

gymnastics that they should be considered under that head.

The pulley-weight exercises deserve to be viewed by themselves. They exercise muscles in **anatomic groups,** rather than in such combinations as are found in the ordinary gymnastic and athletic exercises. Putting a dumb-bell to the floor and lifting it again is a single operation physiologically, but anatomically it involves the co-operation of most of the large groups of muscles of the body.

The object of isolating the muscular groups is that each may be given precisely that load which is best adapted for its own development, and thus to produce the maximum of effect upon it. Another

reason is that when exercise is of a local character, it is possible for the vasomotor system to direct to the muscles involved a larger blood-supply than is possible when many groups are exercised at once. The dilatation of arterioles supplying groups of muscles in exercise is effective only when there are not so many groups exercising at once as to demand the bulk of the blood-supply. In the latter case all that can be done is, by means of increased cardiac activity and the limitation of the blood-supply to the abdominal organs, to send a greater proportion of the total quantity of blood to the muscles in general. This accelerates the general circulation of the body. It thus appears that the food-supply of

FIG. 7.—EXERCISE FOR LUMBAR MUSCLES.

FIG. 8.—EXERCISE FOR BACK AND WAIST.

any given group of muscles may be temporarily increased more rapidly when this group is exercised alone, as is done by pulley-weights, than when it is exercised coincidently with a large number of other groups. In the movement referred to—stooping to the ground and rising again—muscles belonging to both sides of the trunk and to all the limbs are brought into play. The result is an increase of the circulation throughout the whole body. This, however, does not correspond to the degree of local physiologic effect that is produced when these same groups are exercised separately. We thus see the primary indication for the use of pulley-weight machines. They are excellent to **develop weak parts,**

to bring into activity muscular groups that for some particular reason are behind their fellows. It is possible in connection with the various attachments of these pulley-weight machines to exercise almost any of the larger groups of muscles of the body and limbs. By taking them in rotation, all the muscular groups may well be exercised in succession.

There is, however, another way in which these machines may be used with a resultant effect that is quite different. In using a dumb-bell advantage is taken of the downward pull of gravity to furnish work for the muscles. In the same way exercises of a general character may be done with these pulley-weight machines, the difference between them and the dumb-bell being that with the former the pull is lateral instead of vertical. A ten-pound dumb-bell is equivalent to a ten-pound weight on the end of a rope, but in the case of the pulley-weight the pull is

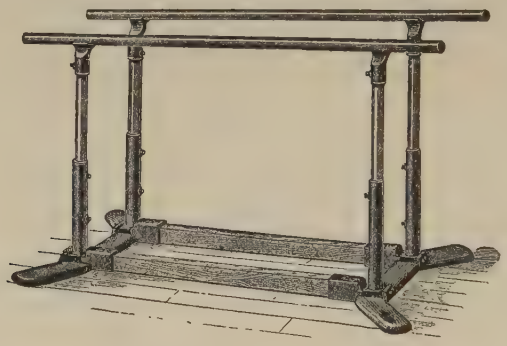


FIG. 9.—PARALLEL BARS.

exerted in a horizontal direction. This fact may be taken advantage of in altering some of the muscular leverages of the body by one of the so-called 'chest-weight' machines. These are pulley-weight apparatus in which the handle is approximately at the height of the shoulders. Let a person stand sideways to one of these machines and take the handle with the proximal hand, pull it to the floor, extend it along the floor as far away from the machine as possible, then lift the handle as far vertically as possible, and ultimately let the handle come back to its original position. In this we have a movement as general in its effect upon the muscles involved as any done with the dumb-bells. The effect upon the muscles of the trunk differs, however, in that the effort involves far more of a lateral pull than when it is merely gravity that is being resisted. Such an exercise is not a movement of muscular isolation, and it therefore produces the general effects of exercise upon the

body and its organs. There are, moreover, mental reasons for the use of such apparatus. Many patients require that something shall be done which appears impressive. The power of **suggestion** is most potent even in the attainment of physiologic results from exercise.

One of the most common difficulties in connection with the use of these machines is the tendency of most individuals to stand with the thorax in an unphysiologic position while going through the exercises. In prescribing such exercises particular attention must be given to this point. The spine should be kept rigidly erect, with the thorax in the so-called active position.

The use of pulley-weight exercises appears to be but slightly expensive from the neural standpoint, far less so than more complicated exercises

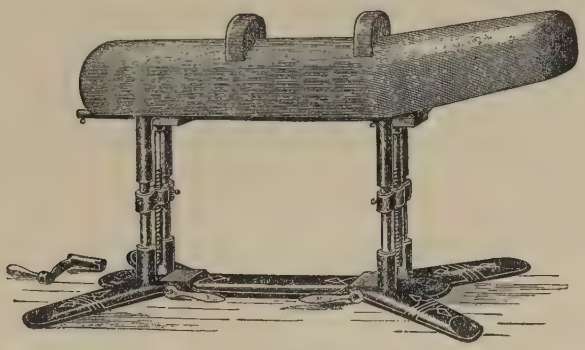


FIG. 10.—GERMAN HORSE.

requiring less muscular effort. This indicates one direction of their usefulness. Business or professional men wishing a general exercise, or one preliminary to general exercise, may be given a series of movements that shall in quick succession exercise the chief muscular groups of the body, and thus prepare them gradually for more vigorous exertions.

4. Heavy Gymnastic Apparatus

It is somewhat difficult to characterize the whole subject of apparatus work, as it varies not only with the kind of apparatus used, but also with the way in which it is used. In general we may say that the object of the apparatus is to afford a stationary support or base of operation for the body. Gymnastic work is thus in contrast with calisthenics, in which the apparatus is moved while the body remains relatively stationary.

Let us examine, first, apparatus exercises in which the individual is engaged for from ten to twenty seconds continuously. During this time the weight of the body is supported almost continuously by the arms. On the rings or horizontal bar, or suspended ladder, the arms are largely overhead; on the horse, or low bar, the arms are held downward; but in both cases the weight is supported from the shoulders. It is the general agreement that such exercise persisted in continuously for a long time leads to enlargement of the shoulder and strengthening of its ligaments, limitation of the freedom of its movements, and the pronounced development of the flexors of the fingers so that the latter are usually held in an almost flexed position. Referring back to one of our original propositions, that **function makes structure,** we see that the supporting of the weight of the body with the arms has resulted in so changing the shoulder-joint as to make it better adapted for the handling of the weight of the body, in this respect becoming more like the hip-joint. If we admit that each part of the body should be exercised in accordance with its natural function, we should condemn such exercises; for the arms have been developed through the handling of objects other than the body. In their natural state the muscles of the arm and chest are competent to hold the body temporarily, but not to do the work demanded of them in heavy gymnastics.

If, now, we use the apparatus somewhat more as an obstacle to get over or around than as something to rest upon, each exercise lasting but a second or two, we shall change the character of the work, and shall overcome the difficulties referred to. It is perfectly physiologic to have the arms support the body for a moment, as in vaulting or climbing, in which the arms and legs are used alternately. This brings us to the **desirable type** of apparatus work, which affords variety without lessening the general effects of exercise. The result is obtained by a larger number of exercises of a more moderate character. Lifting a weight with the two legs is as much exercise as raising it with one arm. The same number of foot-pounds of energy is expended in the two cases. When the weight is raised by the legs, large masses of muscle are used—the work is thus done easily; when it is done by one arm, comparatively small masses of muscle are engaged, hence it is done with difficulty. It is not to be understood that exercises involving more than momentary support by the arms should never be used. An individual who has worked for a year or two will naturally develop in accordance with the growth of his own strength and aptitude. A man with small hips and light legs will do readily what a man of different build could not accomplish without unwise straining. In

general, however, more substantial and better results, especially as to the heart and lungs, are achieved by quick apparatus work with momentary arm support than by exercises under the opposite conditions.

5. Track and Field Sports

Actual competition differs much from training. That which I shall speak of now is the result of the exercise that a man gets who practises moderately. Track and field sports correspond to the more elementary activities of savage life—running, jumping, throwing, and the like. They involve psychic characteristics that differentiate them from gymnastics. There is a joy in doing them that is not usually found in gymnastics.

The quantity of exercise to be derived from any given sport is so limited that sports do not appear to be suited for general exercise. It is difficult for a high jumper to do enough high jumping alone to get general exercise out of it. The jumping is not interesting unless it is high enough to involve an effort in each jump. If it is so high as this, then it is more an exercise of will, co-ordination, and nerve-force than of muscle. A man coming from such exercises, especially when they have been extreme, will find his hands trembling, and will show other signs of neural rather than of muscular fatigue. It may be said that a man should simply make moderate efforts, that he should make none of the extreme efforts that call for the undesirable neural expense. The answer to this is that the formation of such habits is detrimental to the real contest; that the man who trains himself to run slowly will form habits of running slowly, so that he will never be able to run with greatest speed.

Training for **long-distance running** is an exception to much of what has been said about track and field sports. This sport calls almost exclusively for general, rather than for local exercise.

If a man will run quickly through a variety of sports—jumping a little, putting the shot a little, pole-vaulting a little—and not try too hard in any one, he will get a good deal of exercise out of the pastime. But the number of men content to do this is small. Young men before they are twenty-five, who are in the period of final ripening of the neuromuscular mechanism, thoroughly enjoy the keen competition of these sports. For such individuals, it is my belief that the sports themselves are beneficial.

6. Games

It is not possible to characterize the physical activities of games as a whole. They vary from the intense labor involved in football to the

almost exclusively intellectual occupation of chess. We are not now concerned with the more intellectual games; we have to do with those which involve muscular power. The amount of work that can be done without fatigue during games is astonishing. This is especially evident when one considers the fatigue that results from the same amount of muscular work done under the immediate control of the conscious will.

Basket Ball.—There is no game that demands more varied and constant muscular exercise than basket ball; hence, we must note its qualities. The muscular work demanded by basket ball is varied; the large muscles of the back are contracted frequently in stooping; the muscles of the abdomen are exercised vigorously every time the individual starts to run; the arms are in constant motion handling or endeavoring to handle a light object, occasionally in defending the body from running into a piece of apparatus; the legs are in constant and varied activity, and there is great call for action of the heart and lungs; there is much agitation of the abdominal organs. In these respects, basket ball is an ideal exercise. The game has a minimum of local effect. We rarely find muscular groups built up by basket ball, although the game calls for the activity of nearly all of them. It does put them all in a condition of vigorous functioning ability, but it does not usually increase tissue. It does increase the power of the circulatory and respiratory apparatus. The game, when played under conditions of intense competition, involves a strain on the attention, exceedingly rapid starting and stopping, so that the neural expense is great; it is here that basket ball experts chiefly suffer. Before a person is able to play well enough to be a member of a team in which there is intense competition, he has played for a sufficiently long time to become somewhat habituated to it; still the nervously exhausting effects are common. It should be recalled that the game is expending these efforts in lines to which the race, if not the individual, is accustomed; and that accordingly nothing like the same effect is produced by an equal degree of concentration here, as it would be if spent in other lines. This point is important, but has possibly not been much considered heretofore. The same degree of concentration and effort directed in most other lines would quickly exhaust the individual. Even in basket ball few persons are able to stand two intense games a week.

When the game is played rapidly, the organ that is the most overworked appears to be the heart, and it is doubtful if this difficulty can be obviated without altering the game as a whole. Allowing one minute's rest for every five minutes of play might help, but even here the absolute quantity of work done by the heart remains the same. For a person who

shows any sign of nervous exhaustion, the intense competition of any such game as basket ball must prove unqualifiedly injurious. If we remove the more intense competitions, and use more of the recreative element, we achieve an excellent physiologic, neural, and psychic result.

This discussion of basket ball may perhaps serve to indicate the **general characteristics of useful games,** and the way in which one can arrive at conclusions in regard to their usefulness. The following questions answered about any given game will give useful information:

Does it involve frequent contraction of the great muscular groups of the body? Does it demand moderate efforts? What are its effects upon the heart and lungs? Does the game keep the chest in such a position as to interfere in any way with the functions of circulation and respiration? Are the various series of contractions intermittent, so that the muscles have time to recover their tone, and are not overcome by fatigue? Is the danger of competition such as will lead men to excessive expenditure? Are there any parts of the body that are so called into action as to render their development excessive? Is the game adapted to the stage of life of the individuals for whom it is designed?

7. Wrestling, Boxing, Fencing

Putting these exercises in the order of muscular strength, and the inverse order of skill demanded, we say, first, wrestling; second, sparring; third, the various forms of fencing. Actual work in any of these three is so dangerous, and accidents are so common, that only practice or training, as distinguished from contesting, is to be considered as available for exercise.

Wrestling is so much a matter of weight as to be done always in classes, and it is but rarely that a man of one class is fitted to compete with those of a heavier class. The individual efforts are great; they follow each other rapidly, and the exercise therefore violates some of our fundamental laws. It may not, however, be at all out of place to have wrestling movements done in pairs in gymnasium work, no throws being allowed on the floor, holds and breaks alone being counted. The great interest that most people have in these exercises is evident to all. It is to be explained upon the hypothesis of their importance from the racial standpoint. No other exercises are so likely to be associated with anger, because, I suppose, anger was associated with fighting in the beginning; and it is only one of the achievements of modern civilization that a great battle can be fought without personal animosity between those in charge.

Sparring.—Anger has been associated with fighting so long that one instinctively comes into a state of mind of belligerency and readiness for

anger even when practising sparring. Sparring demands more from the nervous system and less from the muscular than does wrestling, although both of these demand much from the heart and lungs.

Fencing demands a maximum from the nervous system, and not a great amount from the muscular system. The thighs are held in a position that is fatiguing, more from holding the positions than from the active exercise involved. This static contraction of muscle is far more expensive than contraction with relaxation, because it demands the steady innervation of the groups involved, as well as because it does not favor the circulation of the blood and lymph. Those who fence much acquire a more or less marked scoliosis, a lowering of one shoulder, and an undue development of the fencing arm. The attention must be held in fencing as in no other exercise. It must never for a moment be relaxed. The movements must respond with the greatest speed to the direction of the will. Thus, we get the maximum of neural expenditure with a comparatively small amount of muscular work. This does not appear to obtain in practising the **single-stick** drills and other exercises, which are really calisthenics done in the form of fencing, but appear to be more interesting than most other forms of calisthenic exercises.

Thus, with reference to track and field athletics as well as these three combative exercises, it may be possible to secure gymnasium work from them that shall be definitely interesting and valuable on account of the psychologic setting of these activities in the history of the race.

8. Bicycling

So soon as the wheel has been thoroughly mastered, riding becomes largely an automatic process. The chief labor is accomplished by the extensors of the thigh and leg. These being large groups of muscles, the circulation and respiration as well as the general nutritive activities of the body are stimulated, the acceleration being directly in proportion to the number of foot-pounds of energy expended. Pursued at a moderate gait, and for moderate distances, bicycling is in many respects an ideal exercise. So soon as the speed becomes extreme, as with all other exercises, we find neural expenditure becoming great, for the motor centers must be consciously stimulated and the attention must constantly be given to the work itself. This is equally true when the exercise is unduly prolonged. When one becomes accustomed to the wheel, riding from ten to fifteen miles daily, at the rate of seven to eight miles an hour, over a good road, is moderate exercise. Riding more than twelve miles an hour even on a good road is rather severe exercise. Since the production of saddles that allow the weight to be

sustained by the tuberosities of the ischium, objections that formerly obtained in regard to the wheel have been largely removed, and thus do not need discussion here. One respect in which walking and running are better than bicycling is that the trunk is agitated far more by the former exercises than by bicycling. Thus, circulation in the abdominal organs is stimulated more in the one case than the other.

9. Golf

One of the forms of exercise now coming into great popularity is golf. It needs no extended discussion, for its advantages and limitations are manifest from previous discussions. It involves considerable time spent out-of-doors, hence is exceedingly advantageous. It involves a large amount of walking; the attention is constantly engaged, and is thus kept from reverting to business and other cares. This is a great point in its favor. The exercise involved in it, while somewhat extended, is of a moderate character. It is thus evident that there are few exercises that afford such excellent opportunities for middle-aged men and for women of all ages, for whom more severe exercise would be out of the question. Its great advantage is that interest in it is maintained for years.

Horseback-riding

The peculiar effect of horseback-riding is due to the up-and-down motion of the horse, which agitates the abdominal organs. This is effective in proportion as the gait of the horse is hard or easy. The necessity for the balancing of the trunk while gripping the saddle with the knees, gives to the rider the general effects of exercise. In its effect upon the abdominal organs, notably the liver, we get marked results from horseback-riding. The gait most active therapeutically is, of course, the **trot.** There is a kind of delight that many persons take in this exercise that is in its favor, and must be borne in mind in ordering it.

Bowling

This is a form of exercise often exceedingly enjoyed by business and professional men, although not so much so by young men. Unfortunately, the ventilation in bowling alleys is usually poor. The exercise is moderate and in the main excellent, although it is of a somewhat one-sided character. I have failed to see any unfortunate results from bowling even when it is indulged to some excess. The interest in the game is such as to warrant its being used as a general form of exercise.

Rowing

Ordinary rowing in a row-boat differs markedly from the effects of rowing when it is done in a shell on sliding seat and at racing speed. In the former case, it may be classed as a general exercise of moderate severity, with particular effect upon the forearm, shoulders, and back. In the latter case it is an exercise of great severity, with chief effect upon the thighs, back, and forearm, and particularly upon the heart. For purposes of general exercise, this latter style of rowing may be left out of account. The one important point to be kept in mind in connection with ordinary rowing is that the back should be kept flat; for in this condition alone are the heart and lungs operating to the best advantage.

Relation of Physical Exercise to Age and Sex.—Let us now consider the application of the whole foregoing discussion in relation to age and sex. Let us follow the needs of the growing organism from infancy to old age, observing the place that muscular exercise has in each period. In general, it may be said that the importance of muscular exercise decreases with every succeeding year of life. The infant without muscular exercise would fail to develop fundamental physical as well as psychic qualities. All that is needed for the exercise of the infant is opportunity. Freed as much as possible from the restraints of clothing, the infant should be allowed to play freely for considerable periods every day. The instinctive play of mothers with their children seems to be an entirely rational process, an agency which through natural selection has tended toward the development, and hence the survival, of the young. The study of these instinctive mother-plays form an interesting commentary on the order of development of the child's neuro-muscular system and his sense organs. They are, however, done by the mother without any conscious educational purpose.

Soon the play instincts of the child lead it into experimentation with all the objects at hand, and in all available ways. It will play with sand, with blocks; will run, will throw. The order of development of these plays is, in the main, a definite and logical one, from the simple to the complex, from central to peripheral movements. During the first six or seven years of life the child will take ample exercise if given opportunity to do so. All that is necessary is to furnish the implements. It is far better to have these implements of the kind that allows the child to exercise his own constructive instincts than to give him complete toys, such as railroad trains, wind-mills, and the like. No possible scheme of physical training can do as much for the child as his natural play; for

his natural play is the result of selection working through the unfathomable ages of evolution. At about seven, games come to be of predominant interest to children, particularly games involving the element of competition. It is here that the various forms of tag are developed, such as 'cross tag,' 'prisoner's base,' 'black man,' and the like. Elementary games of ball, 'hide and seek,' 'duck on the rock,' games with marbles, 'leap frog,' begin to be attractive, and the child develops an interest in track and field sports. The care of land and the love of animals is accentuated during this period, and the instincts for hunting and fishing usually assert themselves. This period represents the ontogenetic acquirement of those capacities that precede the dawn of even barbaric human life. It represents a stage in which the individual depended upon individual combat for existence. During these years the physician will have to be careful that the number of hours taken for school work does not so encroach upon the hours of play as to render these racial achievements impossible. The boy or girl who has opportunity for the playing of games, who has a sufficient number of playmates, and sufficient space to play, will be found to develop suitably. Cities are being built up so compactly, however, that it is becoming necessary to make special efforts to get playgrounds. This is already being done in most of the large cities, and the movement will be favored by all who consider the organic requirements of the individual during this stage of life. Play is far more important for the child's development than formal school educational gymnastics during these years. Through these plays, bodily skill as well as vigor of heart and lungs is gained, and the muscles are called upon for constant and varied activity. It is true that they do not seem to have the logical development that can be found in systematic gymnastics, but I believe that this is only a seeming lack. If one considers the plays and games of boys and girls during an entire year, he will find a progressive and most complicated and elaborate scheme. It is true that during the marble season boys will play but little else than marbles, but the season is soon over. It is followed by top season, or kite season, or some other sport. These sports have a seasonal rotation, and occur every year with more uniformity even than the seasons. The time for marbles or tops can be predicted with far more accuracy than can the arrival of robins or the advent of spring. If one looks at the range of sports covered in this methodically haphazard fashion for a year, it will at once be evident that the curriculum of sport is a rather complete one. It will be evident that the child during the year has had exercises for skill of hand, quickness of eye, the development of the muscles of the trunk as well as of those of the limbs;

that heart and lungs have been given vigorous training; and, in fact, the whole organism has been called into play in a way that is entirely impossible by gymnastics. We have already seen that gymnastics deal largely with the chief muscular groups. The neuromuscular plays of boys and girls include not only all the muscular combinations developed by gymnastics, but the finer muscles of the hand, of the face, and of the larynx as well. Play also includes an emotional development and a training of the will; it involves self-control and the development of those instincts of competition and self-reliance which are basal to the development of character. Gymnastics seem more logical, but are in reality far less so.

The human embryo in coming to term, passes in gross outline through the life-history of the race from the amœba up. Conscious human guidance is not only unnecessary but would be injurious in the endeavor to guide the development of the cells. The developing embryo does not start directly toward the adult human form. It pursues a most circuitous route. This is equally true in regard to the child's development after birth. Nature's forces are competent to lead to the full development of the body whenever they are given the opportunity to do so. One element that must be conserved by human consciousness is the environment favorable to play which civilization constantly tends to remove. Human society has developed far more experience than has become incorporated in the neural structure of the individual. Thus, conscious education in matters that relate to elements learned during the civilized life of the race must be taught by society, and schools are therefore a necessity; but the basal elements of education—the development of the body, of the feelings—may be trusted wholly to nature. She needs but the opportunity. The embryo of the chick is enveloped in the shell. In many respects it would be fortunate if the play life of the child could be similarly enveloped in a shell, so that civilization could not take away that which has been its means of development from time immemorial. City life is bringing large numbers of children close together. This is in itself not wholly normal; hence, there must be a kind of supervision of plays to prevent the evil effects of such undue crowding. This, again, merely represents the effort to supply nature with her customary environment.

Approximately at puberty, interest culminates in the great Anglo-Saxon sports of **baseball, cricket, hockey, shinney, basket ball,** and the like. These great games are played in teams in which the individual is subordinated to the whole. They represent a later evolutionary stage than do the games of the preceding period, which are individualistic.

They are interesting to the physician because of their physiologic character. They represent the extreme form of muscular exercise—extreme not only with reference to individual efforts, but extreme in duration. The extreme example is found in **football.** Not only does each individual make many efforts of as powerful a nature as possible, but he makes them rapidly, so that a rare degree of endurance is demanded even in an ordinary game. A man without special training cannot play even four or five minutes without becoming sore. It is my opinion that these extreme forms of exercise are related to the final toughening of the individual for the achievements of life. They represent the final ripening of the muscular system and its development into full functioning ability. They represent also that development of the large motor centers of the brain which is certainly related to the capacity for continued severe intellectual labor during subsequent years. In the light of its immediate effects, I do not believe that football is justifiable. In the light of its relation to the development of power, I believe that it is justifiable where it can be suitably controlled and limited; but many individuals have attained these same effects through severe manual labor on the farm or in the shop without the physical or psychic dangers attending certain phases of football play. It is only fair to add that an analysis of football accidents shows that they are in the main due to (1) playing when one is not in training; or (2) allowing boys to play against those notably heavier than themselves; or (3) allowing those to play who are too young, too slight, too weak, or too awkward. Mass plays and tripping always involve some degree of danger. In some way, however, every adolescent ought to do muscular labor of considerable severity for a considerable period. Is it not interesting to note that these severe exercises are brought about instinctively by nature through the tremendous interest in athletic sports during these adolescent years, and that these activities take the general form of the combats of savage tribal life?

After the age of twelve, it will be necessary for the physician in many cases to order **special exercise.** The intellectual life is commencing to be of dominant interest to boys and girls. Public opinion, as well as the lack of opportunity, may prevent them from gratifying the instincts which, as we have seen, lead to bodily development. The physician will often have to say that the boy or the girl must be given opportunity for exercise. Out-of-doors exercise is best, and it should be more or less in accord with the native interests of the period. Camping out in primitive style, with hunting and fishing and many other savage occupations,

seems to be an ideal form of physical life. But that which is most desirable is usually least possible; it often happens that for lack of place and time the individual cannot take advantage of the natural instincts. Under these conditions, what is to be done? The individual must work in a gymnasium. Under what conditions will the best results be attained? How may the exercises be so ordered as to bring the greatest advantage to the individual?

This brings us to the consideration of the characteristics of gymnasium work when done predominantly from the standpoint of health.

CHARACTERISTICS OF HYGIENIC GYMNASTICS

1. The day's exercise should begin and end either with work for the smaller groups of muscles, or with graded work for the larger groups of muscles. Thus, the heart and lungs are gradually led up to and away from the severest effort. The muscles themselves are not suddenly called on for their most intense work. This is the fundamental idea contained in the Swedish "day's order." It may be true that we terminate actual gymnasium work with the maximum of effort, as by a run, or a basket ball game; but it must not be forgotten that following this is the walk to the dressing-room, the bath, the rubbing down, the quiet dressing and sitting around, and the going about one's business. The entire curve showing the intensity of effort must take these details into consideration.

2. Each part of the body should be exercised in general according to its natural function. This refers to the quantity as well as to the character of the work. Thus, the great muscular groups of the body should do a large amount of hard work. The heart and lungs should be called on for activity, the arms and shoulders should be called on for skill and quick work, the legs for power and endurance. As the individual advances in strength and power from year to year, more and more weight may be handled to advantage. This is the normal progress of individual growth and development, and no absolute standard can be fixed. While in the individual unaccustomed to exercise, the body should not be supported by the arms for any length of time, the same caution does not necessarily apply after one or two years of effort. In most cases this prohibition would take away work on the high horizontal bar from the first year.

3. Each individual muscular effort should be well within the capacity of the performer. It not only should be absolutely moderate, it should be relatively moderate. That which is moderate for a strong man would

be excessive for a weak man. For a man who has just come to the gymnasium moderate work would be needed, which would be absurdly insufficient for a man who had done a year or two of work.

4. There should be a large number of individual exercises. Thus, the sum total of the work done may be considerable. The stronger the person, the stronger the effort that he can make to advantage. It is thus important in invalids to begin with minute doses, and to proceed by steadily increasing stages toward work that will demand and obtain the larger activity desired. Again, the individual thoroughly accustomed to exercise will derive but little benefit from such minute doses; the doses must be adapted to the degree of strength and habituation of the individual.

5. So far as possible, the exercise should correspond to the psychic needs of the stage of development of the individual who is exercising. Thus, the needs of adolescents are not the same as those of business or professional men. The fundamental psychic characteristics of each group must be constantly kept in mind. The play of adolescents represents great needs that cannot safely be ignored, as they are intimately associated with the deepest interest of the individual. Whenever it is possible to introduce simple elements of competition with adolescents, it is well to consider the advisability of doing so, as this is the natural period for competition, and the great interest that is aroused in contests should be jealously guarded.

6. It is important that exercise be considered constantly with reference to the position of the trunk. For this great lesson we are indebted, as already stated, to the Swedes. We cannot afford to play games or do exercises in which the trunk is thrown into a position that embarrasses the heart or lungs. The organic functions of respiration and circulation are too important to be interfered with in any way. It must be remembered that the body tends to assume during rest the position it took during exercise; and we must constantly endeavor during exercise to keep the trunk, the ribs, and the spine in that position which we wish them to maintain all the time.

7. The degree of memory and attention demanded from the pupils should be minimized. Thus, they should not do much work that demands the committing to memory of long series of exercises. The teachers should constantly do the remembering for their pupils, teaching the exercises by example rather than requiring the pupil to remember them. The rest of two or three seconds between the movements of the dumbbell drill to observe a new exercise is beneficial to the heart, which beats rapidly during such work in most individuals. The degree of attention

demanded should be enough to keep the mind from other work, and yet should not be of the strained or voluntary character that is demanded in following intricate calisthenics.

School Gymnastics

In this connection it is well to consider briefly the characteristics of such school gymnastics as should be universally introduced. We have already seen that the normal development of the body may be left to nature if a suitable environment be provided. The demands of school life are that children shall remain measurably still for five hours a day, most of the time seated at a desk. In most schools the desks are not adapted to the length of the spinal column and of the arms and legs of the individual, so that unsymmetrical sitting postures are constantly assumed, and growth of the body is correspondingly unsymmetrical. The constant sitting still deprives the muscles of that activity which we have shown to be natural to childhood. By insisting on quiet, we have interfered with nature in two ways: first, by taking away a great deal of time that she usually gives to exercise; and, second, by keeping the child for long hours in a more or less unnatural position. The aim of school gymnastics must be to remedy these two alterations of the environment which are rendered necessary by the demands of civilization. This combating of the effect of the school desk upon the body can best be done by a few minutes' vigorous exercise of the large groups of muscles at frequent intervals. Except when the ventilation in the building is perfect, the windows should be opened at the end of every hour and the pupils should all be given vigorous exercise for two minutes. These exercises should be especially directed to the maintaining of a correct carriage and to the vigorous exercise of the large muscles of the back and thighs. There will naturally be introduced accessory movements of the arms and legs to add variety and increase the interest. The essentials of school gymnastics are correct carriage of the trunk and exercises calculated to strengthen the back and thighs. This will involve increased cardiac and respiratory activity. Such a scheme of exercise as this does not involve difficult exercises nor expert teachers; they can be carried on by the regular teachers. They do not make a very heavy demand on the time given to definite intellectual achievement.

On the other hand, the attempt to secure by school gymnastics complete motor education must fail because of the limited time that under the best of conditions can be given to gymnastics during the school period, as well as because of the limited range of material available as compared with that available during play. The complicated motor

development which forms the basis of later skill in life, even including that of an intellectual character, comes chiefly through the development of the hand, lips, tongue, and larynx. The development of the hand, as shown by Dr. Seguin and others, is of the greatest importance; hence, in motor education, manual training, Sloyd, marbles, work with jack-knife, tools, and machinery,—all seem to have a definite and important place. They are basal to education in the individual as they have been in the race. The object of school gymnastics is to combat the effects of long sitting at school desks. For true motor education, we must depend on play and manual training. Children out of school hours must be given full opportunity to play. In school they must be given opportunity to combat the special conditions presented by sitting still at the school desk. **Scoliosis** is far more common among girls than among boys. It is rarely found among those who have a fair degree of muscular development of the back. Such simple school exercises as we have proposed will in my judgment largely prevent scoliosis in the developing child.

TRAINING MEDICALLY CONSIDERED

It is no part of this treatise to consider the general subject of training from the standpoint of the athlete. We aim to consider those conditions with which the physician may have to deal. The subject may be considered under four general heads: (1) The physical condition of the individual; (2) the special athletic habit that is to be formed; (3) the muscular power involved in the exercise; (4) the endurance demanded. In training for any object whatever, these four points must be kept constantly in mind. Each of them will affect markedly the character and quantity of the work that the individual should do.

1. **Condition.**—It occurs frequently that an athlete is overworked so that there results a condition technically known as 'staleness'—*i. e.*, the expenditure of the body exceeds the income. The income of the body is related not only to the amount of food ingested, but also to the capacity of the several cells of the body to convert this food into active protoplasm. The individual can always eat enough if the food is available; but all individuals sooner or later find a limit to their capacity of converting food into protoplasm. I do not know what the nature of this limitation is, but believe it to be fundamentally a neural one. This condition of staleness will come far more quickly in some persons than in others. Its first premonitory sign is a decrease in weight. Less buoyancy is felt; work is less enjoyable; each effort takes a greater exertion of

the will. This matter of condition is one of supreme importance from the medical as well as from the athletic standpoint. Every athlete should come to his contest at the very summit of his ability and feelings. This he cannot possibly do if he is overworked. Good feelings are indicative of good strength. The slight extra degree of skill that can be secured by excessive training will never compensate for the loss that comes to the one who is overtrained. If the overtraining is serious, breakdown may result; boils are apt to form, and diarrhea sometimes sets in. In former days athletes were far more apt to be overtrained than they are at present; but even now nervous men are prone to be overtrained. One should do every day a little less, rather than a little more work than he can recover from at night. It is a common error of beginners to do all that is possible every day, and to endeavor by force of will to make up for lack of condition. Day after day they force themselves through the exercises that have been laid down for them, even though the muscles remain sore, and they feel increasingly disinclined for the athletic work.

A man should feel like doing his work. He may overwork in two ways: by doing so much in one day as to demand several days for recuperation; or, more commonly, by doing each day a trifle more than he ought to do. In the latter case he adds each day a trifle to the fatigue, and soon comes into a state in which he is liable to colds or any disease that may be prevalent. His whole system is in a condition of depleted vitality. He has but little power of resistance either to unfavorable environment or disease. Overtraining is rendered more probable when emotional or mental strain is added to physical work. It is a common and advantageous practice for the athlete to refrain almost entirely from severe exercise for one, two, or three days immediately before a contest; he thus comes to it with the greatest degree of freshness and vigor.

2. **Habit.**—In every athletic exercise a certain degree of skill is demanded, the acquisition of which consists in the formation of certain habits. A man will never do his best in any sport until he has learned to do it unconsciously, until he is able to put his whole attention into the muscular effort. In the running high jump, for instance, so long as a man has to pay attention to getting the right step, to making the spring from precisely the right spot, to turning his body at the critical moment, he will not jump high. When, however, he has learned all of these points so that he does not have to think about them, he can put his whole effort into the jump itself. He will then do his best. His jumping must become largely an automatic process. His mind must be reserved for the effort itself. This formation of habits is entirely a neural process; it does not relate to strength. The habit is formed not by a few extreme

efforts but by many moderate ones. This illustration from the high jump is not unique; the same general truth underlies all sports. Even in such a matter as long-distance running, the gait must become automatic before the individual can do his best. An illustration of the way in which habits are formed may be taken from the sport already referred to—the running high jump. Let the stick be placed at such a height that it can be easily cleared by the athlete, and let him make this jump a large number of times each day. Eventually starting from a certain distance from the stick, the athlete will find that his feet come with automatic precision into just the right place and that his last stride will carry him into exactly the position for jumping. Gradually the stick may be raised, but it should always be well within the jumping ability of the performer. During the early part of the training, the endeavor to jump as high as possible will surely get the athlete into bad habits. What is imperative in the early stages is the formation of **style.** This can only be done by constant, persistent repetition. Gradually the athlete will be able to put in increasing effort, and thus to jump his best, and still preserve his style. It is the custom among the uninitiated to jump as high as possible every day. The bulk of the trials thus are at heights that are not cleared, with the result that the individual never is able to jump as high as he should and as he could learn to jump by the other method. These general principles apply to all branches of sport in which skill is required.

3. **Strength.**—The development of strength must follow that of habit. Strength, like habit, requires constant and persistent exercise, and is acquired by performing many moderate movements rather than a few excessive ones. The development of the muscle-groups involved in any given form of activity is achieved by the daily persistent exercise of that group rather than by occasional excessive exercise. In most athletics sufficient strength is acquired by practising the exercise itself; occasionally—as, for example, in throwing the hammer—special work can with advantage be given for the development of the back and the sides of the trunk.

4. **Endurance.**—This relates not only to capacity for long-continued exercises, such as long-distance running, but also for the repetition of a single exercise like that of high jumping, which must be repeated a great many times. It involves respiratory and cardiac capacity, and, equally with these, power from the motor centers. Endurance in long-distance running is most often found in those with long trunks. This I believe is related to the larger space afforded for the heart and lungs. Let us picture the central operations in a man beginning to run rapidly: the

large and powerful muscles of the legs, thighs, and trunk are contracting with great force and frequency. Steps are being taken approximately at the rate of four a second. Each step is about six feet in length. At this rate he is running 100 yards in 12½ seconds. The large muscles involved press the blood contained in the veins toward the heart, which in turn immediately contracts with greater vigor and rapidity, forcing a return current of blood into the arteries. The blood from the muscles is thrown into the lungs. The pulmonary capillaries are dilated a trifle more than usual, which limits somewhat the total superficial area of exposure to the contained air—a condition of temporary embarrassment supervenes, known as being 'out of breath.' The muscles of the legs soon ache, and the runner lessens his speed. The heart beats with increased rapidity, gradually a balance in respiration and circulation is restored, and the individual comes to what is known as 'second wind.' One of the objects in training is to make this preliminary process as rapid as possible. It is possible for most athletes to reach a state of training in which there is no initial embarrassment. The whole apparatus meets all the demands made upon it and operates with force and vigor until the motor centers are too much exhausted to permit of the exercise being continued. Such endurance is acquired only by practice. Generally that practice is best which is most nearly analogous to the exercise involved. In training for rowing, endurance is often acquired by running, because running demands less attention than rowing. If the individual rowed enough to gain all the endurance that is needed, he would probably do the latter part of it in a slipshod way. This would make toward the production of bad habits. There should be no rowing except when it is done with the very best possible stroke. This general principle of *doing exercises only when they can be done best* is an important one, and must constantly be kept in mind.

SYSTEMS OF GYMNASTICS

Up to this point we have been considering the general principles underlying the use of muscular exercise as a therapeutic agent. Let us now examine in brief the various **gymnastic systems.**

German Gymnastics.—In the latter part of the last century there was much interest aroused in educational circles through the work of **Gutsmuths,** who was a broad-minded, scholarly teacher of gymnastics. Early in this century, **F. L. Jahn** began a most active propaganda in

favor of general physical training. He was a patriot and felt that the salvation of the nation depended upon the building up of a strong people, and in physical training he saw a major means to this end. His primary interest in physical training was a national or political one. He is known as 'the father of German gymnastics.' His work was largely based upon that of Gutsmuths. The exercises used and the apparatus devised were chiefly of the spontaneous kind: running, climbing, throwing, jumping, wrestling, sparring, swimming, were all vigorously practised. There gradually arose the pieces of gymnastic apparatus—the German horse, parallel bars, and horizontal bar. Teachers and pupils alike strove to invent new exercises. There was no special physiologic study of the effects of these exercises. The empirical result was seen to be good. A little later in the century a pedagogue arose by the name of **Spiess,** who systematized and classified all of these exercises, particularly all the exercises that could be carried on in the school-room. He is known as 'the father of German school gymnastics.' His influence has been profound upon the whole system of German gymnastics, removing them from the plane of natural and spontaneous exercise to the rigid observance of schemes and plans. The exercises were arranged with reference to their adaptability to the school-room rather than upon a physiologic basis.

In the middle of this century there was a considerable influx into this country of Germans—embracing political exiles and others—who maintained their individuality. They organized societies for the carrying on of German gymnastics, and the German **Turnvereins** of to-day are the continuation of these societies. They have gradually departed somewhat from the corresponding societies in Germany, but not in essential matters. Much emphasis is laid on exercises performed with various types of heavy apparatus. Thus, we see a great deal of work upon the horizontal bar, the parallel bars, the German horse, and the like, which when unwisely used result in the physique and carriage of the so-called typical gymnast: his shoulders are often pulled forward through the overdevelopment of the pectorals; his chest is not large but has large muscular masses upon it; his shoulders and arms are superbly developed, his legs only passably so. His carriage in walking or running is usually rather heavy. In all exercises involving the support of his own body by the hands he is thoroughly at home, while in running, jumping, pole-vaulting, boxing, wrestling, and particularly in exercises of endurance, he is uncomfortable. The gymnasium exercises of a given individual in the course of an evening's work are arranged primarily upon physiologic principles. The German Turnvereins have been more successful than

any other organization, except the Young Men's Christian Associations, in maintaining institutions for the carrying-on of popular gymnastics. The character of their work is related to the German temperament—American young men do not usually remain members of their societies long. German gymnastics are essentially national in character; they involve patience and thoroughness, they demand hard work and continuous effort; but they do not seem to afford the opportunity for the kind of sport which is the national heritage of the English-speaking people. The German is almost exclusively individualistic in his gymnastics and athletics, while the Englishman and American go in very largely for team games.

Swedish Gymnastics.—Early in the century a man of rare scholastic ability, **P. H. Ling,** awoke to the importance of physical training, particularly, though indirectly, through the work of Gutsmuths. He eventually located in Stockholm, and worked out several different schemes of exercise. The one with which his name has been most prominently identified was a plan of exercises for schools—the so-called **Swedish educational gymnastics.** He also laid the basis for the Swedish movement cure, Swedish military gymnastics, etc. The groundwork for this scheme was physiologic. Exercises always follow each other in a definite order, the reason for this order being their effect upon the body in various ways. The plan is strictly progressive, the movements being arranged in groups in a sequence of difficulty. Thus, if we should put in ten parallel columns the ten chief groups of exercise, and arrange the exercises in each column in the order of their difficulty, beginning with the easiest and ending with the most difficult, the first exercise of each group would form the first day's exercises, the second day would be devoted to the second exercise in each group, the third day to the third exercise, and so on. Thus, each day would see an advance upon the preceding day, and yet the sequence of the exercises and their physiologic relations to one another would not alter from day to day. The curve of effort was studied most carefully. The pupils were all to be exercised in the regular dress of the school-room between two study periods; thus, they could not exercise sufficiently to make them perspire, which would necessitate a change of clothing. The exercises had to be adapted largely to the school-room. The biologic science of Ling's time was exceedingly crude; and for this reason, as well as on account of the characteristic of Ling's mind, much of his physiology is fantastic.

The **three essentials** of Swedish gymnastics are:

1. **The day's order,** which is the physiologic sequence of the exercises carried on each day.

2. **The gymnastic progression,** which is the sequence of the movements from day to day.

Of these two I have already spoken.

3. **The movements are always done to word of command,** and are not learned by imitation. The reason for this last point is that the will of the pupil may be wholly engaged, and thus better execution secured.

Ling intended, and most of his pupils have maintained, that these educational gymnastics form a complete system of physical education designed to bring all of the bodily powers to healthy maturity. From this standpoint Swedish gymnastics are not defensible, for they lay insufficient emphasis upon endurance, that capacity of heart and lung, which we have seen to be of great importance. Furthermore, they require the constant voluntary attention of the pupil, and are thus as far removed as possible from free play. It should be said, however, that Swedish gymnastics were never designed to take the place of free outdoor play.

The most modern authority on these gymnastics, however, has taken a far more defensible position in regard to Swedish gymnastics than have his predecessors. He maintains that the fundamental object of the school gymnastics is a corrective one, designed to combat the effects of the school desk upon the organism. He maintains that sitting at a desk four or five hours a day develops a tendency for the spine and shoulders to assume an abnormal position, and that Swedish gymnastics have their chief claim to consideration because of the stress laid upon the proper carriage and movements of the trunk. He also admits that Swedish gymnastics should lay no claim to be a universal plan of neuromuscular education.

The details of the day's order and of the gymnastic progression have also been modified in ways that the earlier teachers of Swedish gymnastics would have called radical. Whatever may be thought of these details of Swedish gymnastics, the following general conclusions will probably be accepted by most authorities:

1. That Swedish gymnastics do secure good carriage of the trunk; and that they are adapted to combating the evil effects of the school desk upon the pupil.

2. That they do demand close attention from the pupil, and hence must not be regarded as in any sense recreative in their character. They cannot take the place of play. They demand the same quality that study does—attention.

3. That they do not afford, nor is it claimed that they afford, a general plan of physical education.

English Physical Exercise.—In considering this different type of gymnastic exercise, we shall inevitably appear to place Swedish gymnastics and English gymnastics upon the same plane, whereas they cannot justly be placed upon such a plane. The German gymnastics are popular and universal. They are carried on not only in the schools, but by the German Turnvereins wherever German people are found; whereas the Swedish gymnastics are largely the product of governmental activity. There is a strong, new movement in Sweden for carrying on popular gymnastics; but the popular characteristics of these gymnastics are more like the German system than they are like the Swedish educational gymnastics. In England, on the other hand, the exercise is largely carried on not for the sake of the exercise, but for the sake of the sport. To be sure, there are gymnastic societies. For many years there has flourished in London a German Gymnastic Society, which has done splendid work, and there has gradually grown up a school of English gymnasts who follow the German lines very closely. There is also another group who have followed the Swedish principles, and are carrying on a more or less successful work.

For all that, the great bulk of the physical training carried on in England is not to be characterized as gymnastics at all. The English school-boy, with his long vacations and frequent holidays, improves his time not by gymnastics, but by athletics. His characteristic games and sports and exercises are running, jumping, throwing, wrestling, boxing, cricket, football, lawn tennis, hunting, fishing, horseback-riding, rowing, mountain-climbing, and so on. These exercises furnish conditions more similar to those under which the body was developed in evolutionary times than do the more or less artificial exercises of the gymnasium. Each part of the body is exercised in accordance with the way in which it is developed; the heavy work is done by the legs, work demanding speed and agility is done by the arms; the arms do not support the weight of the body for long periods as they often have to do in systems of gymnastics. It is true in theory that in the gymnasium all of these exercises—or at least exercises demanding similar qualities of body and mind—may be carried on; but as a matter of fact it is well-nigh impossible to realize this aim.

Thus, if we compare the typical all-round German gymnast with the typical all-round English university athlete, we find a real contrast. The typical English athlete is the man who has never given particular

attention to muscular development of any kind. He is fairly strong, is erect and graceful. He is a fleet runner, and has splendid endurance. He rides horseback; can spar and wrestle. He has played his game of football, and has rowed on one of the many crews in his university. He is quick, hardy, can take care of himself in an emergency, is used to handling himself in a crowd. He cannot do any particular gymnastic feats with skill, nor is he much interested in them. During later life he will drop his active participation in most of the more strenuous sports; but he will ride, play golf, swim, row, and will always maintain a keen interest in these things. The typical gymnast who has worked for a period of years in a gymnasium has powerful arms and shoulders; the individual fibers of the muscles stand out prominently; he has a powerful grip. The muscles upon his chest and shoulder-blades are prominent. His chest appears large; but this may be due rather to excessive muscle than to the position of the ribs; the thorax is rather flat from repeated severe exertion of the abdominal muscles. The muscles of the legs are vigorous, but are light in proportion to the development of the shoulders and arms. He can do almost anything on the apparatus when suspended by his arms, but he cannot run for long distances, and is not graceful as a walker or jumper. He is not particularly interested in athletics; football he regards as brutal. He is not accustomed to handling himself in a crowd. All his exercises for years have been with reference to handling himself as an object rather than with handling other things or persons as objects. The fundamental difference between gymnastics and athletics appears to be that in athletics the results to be sought are objective, they relate to number—as to space in jumping, time in running, etc.; whereas, in gymnastics they relate more to the form in which the movement is done and hence are subjective. The athlete competes against time and space—the gymnast in self-control.

Delsarte.—The system of gymnastics which is known by this name is one of the most unsatisfactory to discuss that the teacher meets. Delsarte was a Parisian; his aim was to train the individual so as to be able to express the most fully by means of the body all emotion and thought. He devised no system of gymnastics, although he did have certain movements which, he maintained, aided much in securing perfect control of the body. Thus, his school is essentially a school of expression, and in no essential respect a school of physical training. Followers of his, particularly in this country, have taken exercises taught by himself or by his pupils, and have constructed from them a

so-called system of gymnastics; and one of the most prominent has even gone so far as to teach a system of 'Delsarte for health.' The work done is good, the results are excellent; but in what respects they can be called 'Delsarte,' I do not know.

There has also grown up a school of **society gymnastics**—how to stand, how to sit, how to go upstairs, how to carry the arms and hands, how to carry the head and neck in the most approved style, etc. Much of this is excellent, but cannot rightfully lay claim either to the name of Delsarte, or to be a system of physical training.

Sargent.—The most original contribution to physical training that has been made in America is that of Dr. Dudley A. Sargent, of Harvard University. There had previously been in use in one or two places machines in which a rope passing over a pulley had a weight attached to one end and a handle to the other. Pulling on this handle in various positions was utilized as a means of muscular exercise. Dr. Sargent took this undeveloped mechanism, and differentiated a large number of machines adapted to exercising nearly all of the chief muscular groups of the body. The weight attached to the rope is made variable so as to be suited not only to the size of the muscular group to be exercised, but also to the strength of the one exercising. These machines have come into exceedingly wide use, and no American gymnasium would be considered complete to-day without some of them. Their usefulness seems to depend upon the following facts, already discussed more in detail: Muscles can be built up more rapidly when exercised separately than when large numbers are exercised together, for they can be better supplied with blood and lymph when exercised a few at a time. The use of the apparatus is not attended by danger of any kind; they are adapted as well to the exceedingly strong as to the exceedingly weak. The variety of exercise involved is considerable. By means of intelligent use of the various machines it is possible to develop nearly all of the muscular groups of the body, and hence many have maintained that this is a perfect system of physical training. But it must not be forgotten that the general effects of exercise are far more important than the local effects upon individual groups of muscles. A man may be perfectly developed in the way suggested and still have but comparatively little strength of heart or capacity of lungs, both of which are of more importance than great muscular development. Then, again, the development of muscular power in the way suggested does not aid particularly in the acquirement of those capacities for co-ordination—those acquired reflexes, that are so prominently demanded in athletic sports and that

give to the individual more perfect control of his body. Those who have developed themselves to the full extent by means of these machines, having become the modern strong men of the college, are not as a class men who are able to use their strength either for continuous periods—such as distance running—or in ways that demand skill—wrestling, boxing, and the like. They have simply developed great power of individual muscular contractions.

The mistake of supposing such development to be an universal system has not been made by Dr. Sargent himself, for he is an earnest advocate of other forms of muscular exercise as well.

Emerson.—Mr. C. W. Emerson is one of those whose work is far better than was its formulation. Among teachers of physical training he is not recognized as an authority. His work is that of the head of a school of oratory. The aim of his scheme of gymnastics is to give to the individual control of the body. It is also claimed that in acquiring this control a superb carriage is cultivated and the conditions for health are actively maintained. His system consists of a comparatively small number of exercises which are repeated from day to day and from year to year. These exercises are all done without apparatus of any kind. The two principles upon which his work depends are not usually understood, for they have not yet been stated with the force which they deserve. He was the first one in America to emphasize the great importance of the **position of the trunk** with particular reference to the health of the contained viscera. He has long maintained, and his position has been sustained by modern investigators, that visceral prolapse to a slight extent is more or less common in all individuals whose chests are relaxed and whose abdomens are protuberant. He has shown further that the position in which the spine is erect and the ribs in the so-called 'active position' favors the return of the thoracic and abdominal viscera to their normal positions, and thus tends to restore their normal functions. The unscientific way in which this thought has been stated has prevented its author from receiving the credit for it which he deserves.

His other major thought is that a comparatively few exercises, all of which tend to give to the individual **control of himself**—poise, balance, and the like—and all of which also tend to put and keep the trunk in the best possible condition, are better than a far greater number of exercises which cannot be done equally well. He therefore says that the best progression in the physical training of the pupil is a progression in excellence in the performing of these exercises.

It is thus seen at once that Emerson's is not a general system of

physical training. It does not aim at cultivating endurance nor does it achieve the general effects of exercise. It aims to give good carriage and graceful control of the limbs. These two ends are accomplished with considerable success, as many of his pupils will bear witness.

Young Men's Christian Associations.—During the last thirty years there has been gradually developing in the Young Men's Christian Associations of the United States, partly by the process of natural selection and partly by deliberate effort, a scheme of gymnastics specially adapted to the conditions which obtain in these Associations. They now have about 500 gymnasiums with upward of 100,000 active members. The general plan of exercise carried on in most of these gymnasiums is as follows:

1. The day's work begins and ends either with work for the smaller groups of muscles, or with gradual work for the larger groups; thus the heart and lungs are led gradually to and from the severest effort. In many cases the actual gymnasium work terminates with the maximum of effort, such as a run; but it must not be forgotten that this is followed by the bath and dressing, rubbing down, and the like. A curve that shall show the intensity of effort must take this into consideration.

2. It is the aim to exercise each part of the body in general accord with its natural functions. This refers to the quantity as well as to the character of the work. The arms are not allowed to support the body on the gymnastic apparatus for long periods at a time, and there is comparatively little of the so-called heavy gymnastics.

3. Each individual muscular effort is well within the ability of the performer.

4. There is a large number of individual exercises, so that the sum total of the work done may be considerable.

5. In so far as possible the exercise corresponds to the psychic needs and stage of development of the individual. Thus, the needs of adolescents are not the same as those of business men. Competition is deliberately and intelligently used in a restricted way.

6. Great emphasis is laid upon the position of the trunk. This is with special reference to the effects upon the contained viscera.

7. The amount of memory and attention demanded from the pupils is minimized. Thus, there is little or no committing to memory of series of long exercises. The whole trend of the work taught is toward athletics rather than toward gymnastics. Games are used exclusively. The gymnastics that are taught partake more and more of the character of athletics. Thus, on the parallel bars and the German horse few exer-

cises are used in which the body is supported by the arms, but many in which the apparatus is regarded as an obstacle to be overcome in various ways.

DANCING

A separate paragraph may be devoted to the subject of dancing, partly because dancing is the only or the principal form of active physical exertion taken by a comparatively large number of persons during certain months of the year, and partly because of the scanty recognition it has received from systematic writers on therapeutic exercise. Its abuses need not be dilated upon; its uses are to be recognized.

Dancing has from the earliest times been a considerable factor in the physical life of many persons, and its evolutionary and sociologic significance should not be overlooked. The pleasurable features of the exercise and the associated influence of music are no mean factors in its physiologic and hygienic effects. The dancing-schools have been efficient aids in teaching good posture of the body and grace of movement. Dancing itself, consisting of a very large number of movements of the larger groups of muscles of the body, is an excellent exercise from the physiologic standpoint. Heart, lungs, digestion, as well as muscular tissue, are all involved.

There is slowly but surely coming into our secondary schools and colleges a recognition of dancing as a bodily discipline. I refer not to society dances, but to the old folk-dancing, much of which involves bodily movements. This is excellent, and will enrich the physical training program, making it increasingly effective and at the same time increasingly interesting.

INDEX

PAGE

Adolescence, ... 46
Age and sex, relation of physical exercise to, ... 44
Apparatus, gymnastic, heavy, ... 37
Automatic exercises, ... 15

Basket Ball, ... 40
Bicycling, ... 42
Bodily symmetry, ... 25
Bowling, ... 43
Brain, ... 17
" importance of physical exercise in development of, ... 17

Calisthenics, ... 31
Cerebral hygiene, ... 21
Circulation of fluids, ... 13
City and exercise, ... 3
Competition, ... 26
Condition, ... 51
Co-operation among contiguous nerve-centers, ... 18

Dancing, ... 63
"Day's Order," Swedish, ... 48
Delsarte, ... 59
Diseases of occupation, ... 3
Dosage, ... 26

Educational gymnastics, ... 20, 56
Effort, ... 14
Emerson, C. W., ... 61
Endurance, ... 53
English physical exercise, ... 58
Evolution and exercise, ... 2
Excessive and moderate exercises, ... 16
Exercise and evolution, ... 2
" physiology of, ... 9
" position during, ... 11
Exercises, automatic, ... 15
" voluntary, ... 15

Fatigue, ... 18
Fencing, ... 42
Field and track sports, ... 39
Fluids, circulation of, ... 13
Football, ... 47
Footpounds of work, ... 12
Function makes structure, ... 6

Games, ... 39
General effects of muscular exercise, ... 9

PAGE

German gymnastics, 54
Golf, 43
Gutsmuths, 54
Gymnastic apparatus, heavy, 37
Gymnastics, educational, 20, 56
" German, 54
" hygienic, 48
" schools, 50
" society, 60
" Swedish, 56
" systems of, 54

Habit, 52
Health and schools, 4
Heavy gymnastic apparatus, 37
Hepatic circulation, 14
Horseback riding, 43
Hygienic gymnastics, 48

Importance of physical exercise in development of brain, 17
Indian club, 32
Instincts, play, 44
Intrathoracic pressure, 14

Jahn, F. L., 54

Limits of specialization, 24
Ling, P. H., 56

Materia gymnastica, 29
Moderate and excessive exercises, 16
Motor centers, order of development of, 19
Muscle-cell, 9
Muscles, position of, during exercise, 11
" tend to contract even during rest, 11
Muscular exercise, general effects of, 9
" " special effects, 10

Natural function, 48
Nerve-centers, co-operation among contiguous, 18
Neurologic considerations, 15

Occupation, diseases of, 3
Order of development of motor centers, 19
Oxygen absorbed, 14

Peristalsis, 14
Physiologic load, 13
Physiology of exercise, 9
Play instincts, 44
Position during exercise, 11
" thorax, spine, 14
Psychic activity and muscular contraction, 21
Pulley-weight exercises, 33

Relation of physical exercise to age and sex, 44
Running and walking, 29

Sargent, Dr. Dudley A., 60
School gymnastics, 50
Schools and health, 4

PAGE

Scoliosis, ... 51
Seguin, ... 51
Sex and age, relation of physical exercise to, ... 44
Society gymnastics, ... 60
Somatic harmony, ... 25
Sparring, ... 41
Special effects of muscular exercise, ... 10
" exercise, ... 47
Specialization, ... 23
Spiess, ... 55
Spine, ... 14
" position of, ... 14
Strength, ... 53
Structure, function makes, ... 6
Suggestion, ... 37
Swedish "Day's Order," 48
" gymnastics, ... 56
Systems of gymnastics, ... 54

Thorax, ... 14
" position of, ... 14
Track and field sports, ... 39
Training, ... 51
Turnvereins, ... 55

Useful games, ... 41

Vasomotor hygiene, ... 21
Vis naturæ, ... 8
Voluntary exercises, ... 15

Walking and running, ... 29
Wrestling, ... 41

Young Men's Christian Association, ... 62

Zander machines, ... 34